PSYCHOLOGICAL EXPERIMENTS

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J. V. BREITWIESER, A. M., Ph. D.
Professor of Psychology and Education, Colorado College

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To My Wife

Psychological Experiments

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Small numbers refer to the number of the experiment.

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PREFACE

Psychology is now largely taught with constant reference to experimental data. The literature that contains the experiments is so scattered and profuse that it is not readily accessible to the beginning student.

In presenting this list of experiments it has been my aim to offer a series that will supplement the work usually given in connection with courses in the elements of general psychology. Enough work is outlined to keep the students busy for a full school-year in the laboratory. Again, selections can be made for brief courses or for private inquiry.

An attempt has been made to avoid the necessity of using special or peculiar forms of apparatus. The problems and general procedures are given to be worked out in the best possible manner with the materials that can be obtained.

The experiments are given first, the list of materials and apparatus following, so the reader really gets the aim and method of procedure of the exercise in mind before starting mechanically to gather his apparatus.

I have excluded all names of experimental psychologists, valuable as they are, and all data or reports of experiments.

This little book is intended for students who are seeking psychological knowledge at first hand. I hope sufficient details have been given to prove useful to the thinking student.

Blank spaces have been left upon which to record references, special supplemental instructions, important results, etc.

A brief chapter on statistical methods has been presented for the purpose of enabling the student to utilize his results to the best advantage. A careful study of the data from the statistical point of view will often help the experimenter to get more out of his work.

Seven years experience with laboratory students and in courses dealing with students in beginning psychology has led me to believe that a book of the most important experiments, without too much detail, that can be used along with any good text, would fill a long felt want.

The experiments have been gathered from the works of many authors. My chief sources have been, Titchener, Myers, Seashore, Witmer

and Sanford. Many others have contributed something and when they find that I have used some of their material they will know that they have rendered me a great service and that this statement is a grateful acknowledgment.

I have received many valuable suggestions from my former teachers, Professors, J. A. Bergstrom, E. H. Lindley, R. S. Woodworth and James McK. Cattell. My brother, T. J. Breitwieser, has kindly read the manuscript and proof which proved to be an invaluable aid in the preparation of this book. Many errors will doubtless appear for which my friends are not to blame. Their friendly criticism may enable me to do something better in the future.

PSYCHOLOGICAL EXPERIMENTS

CHAPTER 1.

Instructions to Students

A psychological experiment fixes certain standard conditions under which consciousness is to be studied. The value of the conclusions will depend largely on the introspections made during the experimental period.

Introspection is the fundamental psychological method. Every experimenter is conscious, therefore since psychology is the science of consciousness, he carries the object of inquiry with him, convenient for constant examinations. The experiment places the subject under the condition desired for the introspective report. An accurate report of the external conditions is also necessary.

Most psychological experiments require two persons for their performance; the experimenter who manipulates the apparatus and records the results; the subject or observer is the one who is put under the experimental conditions and makes the introspections. All experiments should be performed twice so that the experimenter and subject can change places and each have records.

Read the instructions carefully so as to get the problem clearly in mind. Do not set up the apparatus until you know what you want to do with it. When you have the problem clearly in mind gather your materials and apparatus, and

see that everything is in good working condition. Remember that you are trying to analyze a bit of the subject's consciousness and in no case try to **make records.**

Maintain the same method throughout the same series of experiments. Do not modify your procedure unless there is ample justification. The records made previous to the change will likely prove valueless. Maintain a uniform attitude toward the subject unless the experiment calls for something else. Do not try stunts or tricks for they will vitiate all results. Do not continually ask what the results should be, you have the means by which you can find out. Do not continually annoy other experimenters by asking them for their results. Comparisons are valuable only if properly done. It is more valuable to read the reports of carefully made experiments of psychologists. Do not become discouraged because your results are not accurate. They will likely demonstrate the method and give you many interesting facts first hand. Always refine your methods as much as possible and strive for the greatest accuracy, under the given circumstances. This will give you splendid scientific training.

Learn to overcome minor difficulties yourself, but do not alter everything or change apparatus that is doing the work merely because you think you know more about it than your instructor.

If accidentally or through carelessness you have injured some piece of apparatus report it

promptly, you will thus save time and help the efficiency of the laboratory organization. Laboratory partnerships should be continued throughout the year. It is therefore desirable that congenial partners be chosen as well as some one who can arrange their work so as to meet at times most convenient to both parties. Proper consideration for your partner will cause you to be punctual, considerate, alert and truthful. Should you be unable to keep your laboratory appointment, notify your instructor and your partner. Cooperate in every way toward the accomplishment of the highest grade of experimental work and there need be no doubt but that you will be amply repaid for all honest effort.

Records

Students will need two sets of note books or note-sheets. A daily note book into which to enter the results, introspections, remarks, etc. quickly while the experiments and discussions are under way. As soon as possible the experiments should be worked up and recorded in permanent form. Every experiment should show:—

1. The problem, aim, purpose or question of the experiment.

2. A description of the apparatus and method of procedure. Diagrams, pictures and drawings are very valuable, in describing the apparatus.

3. The results of the experiment in the form of tables, charts, descriptions, etc.

4. A discussion of the results with the conclusions they warrant.

5. The application of the results in life, education, hygiene, etc; also remarks on special points, extracts from references that have a bearing on the same problem, comparisons with members of the class with reasons for agreement, disagreement and other conclusions.

If you have a new explanation to offer do so, if it really seems to you that you have facts to warrant it. The instructor should put you right if you have gone astray. It is better to offer something, even though wrong, than to do no thinking at all.

Have your note book checked up by the instructor. Revise parts that are not up to standard. Turn your note book in for revision with the idea of being helped rather than that of expecting mere praise or condemnation.

Read psychological discussions in texts and journals relating to the subject of your experiments. In the light of your data and facts gleaned from other sources offer the best discussion possible. Go at the work in a true student attitude and experimental psychology will doubtless prove to be an interesting and profitable study.

CHAPTER 2.

Statistical Methods

This chapter is not intended as a **discussion** of statistical methods but the aim is to present the formulae and methods that are needed in every general course in Psychological Experimentation.

For a fuller discussion the student is referred to Thorndike, Mental and Social Measurements; Whipple, Manual of Mental and Physical Tests, Ch. III; Davenport, Statistical Methods and many others who have worked out methods that apply to special groups of measurements.

In psychology a single experiment is usually not enough to warrant a conclusion. It is impossible to keep in mind all of an extended series of measurements. Often a series of results are unintelligible until they have been systematized by the proper statistical method. Statistical treatment is especially necessary in an attempt to condense a long series of measurements, to summarize their tendency or direction.

The Mode

The mode of a series of measurements is the value of that measurement which appears the greatest number of times. A group of measurements may have more than one mode, in this event a more accurate definition of a mode

would be, that a mode is a measure that appears more frequently than the measure above or below it in an ascending or descending order of values.

One way to find a mode is to actually list the number of cases that fall within the range of each measurement, the measurements being taken up in regular ascending or descending order. The modes can be located directly from this data. For the students in experimental psychology it is good practice to plot a curve that shows the distribution of the measurements graphically. When the measurements are so accurate or so distributed that they do not fall into groups, the measurements can be divided into 5, 6, 7, 8, etc., ranges of values and all cases counted in one group that fall within the range of those values. The higher points on the curves of distribution are the modes.

Average

The **arithmetical mean** or average is found by dividing the sum of the measurements by their number.

$$\text{Average} = \frac{\text{Sum of measurements}}{\text{Number of measurements}}$$

$$\text{or Av.} = \frac{\Sigma m}{n}$$

Av. is average.

Σ is sum of.

m is measurements or magnitude.

n is the number of cases from which the record were used.

It is evident that each measure must be accurately recorded and that for a large number of measurements it requires much labor to find the average.

Where a large number of measurements are to be dealt with a **weighted average,** or weighted arithmetical mean will often suffice. This value is found by dividing the whole range of measurements into a limited number of groups and recording the number of cases that fall within that group. The weighted average can then be found by multiplying the measure of each group by the number of cases found in that group and dividing the sum of the products by the total number of cases or measurements represented.

$$Av_w = \frac{\Sigma(m \cdot f)}{n}$$

Av_w is weighted average

f is the frequency or number of cases in each group.

Median

The median or central value represents that measurement above and below which an equal number of cases lie when the whole series has been arranged in an ascending or descending

order. To find the median record each individual measurement in its order of magnitude beginning with either the lowest or the highest. Then count down the series until you find the central measurement.

$$Mn = \text{the } \frac{n+1}{2} \text{ th measurement}$$

Mn = Median.

The median gives little weight to the extreme deviations, which is often an advantage in psychological experiments.

Mean Variation

To find the mean variation or average deviation, first find the average, (mode or median) then subtract each individual record from the average which gives a series of deviations. Add the deviations **regardless of the algebraic sign,** then divide by the number of cases.

$$\text{M.V. or a. d.} = \frac{(\text{av.} - m_1) + (\text{av.} - m_2) + \ldots (\text{av.} - m_n)}{n}$$

$$\text{or m.v.} = \frac{d_1 + d_2 + d_3}{n}$$

$$\text{or, m.v.} = \frac{\Sigma d}{n}$$

m.v. = mean variation.

m. = individual measurement or record.

d. = individual deviation.

Standard Deviation

Statisticians often call for the standard deviation. Many experimenters believe it to be more accurate than the mean variation. It can be found by taking the square root of the average of the squares of the individual deviations. The standard deviation is often indicated by lower case sigma (σ). In psychology this use of lower case sigma is likely to prove confusing because σ is also used to designate "thousandths of a second" in chronometric work.

$$\text{S.D. or } \sigma = \sqrt{\frac{d_1^2 + d_2^2 + d_3^2 \ldots d_n^2}{n}}$$

$$\text{or, S. D.} = \sqrt{\frac{\Sigma(d}{n}}$$

S. D. = standard deviation

If n is less than 50 the formula is often modified by substituting n—1 for n.

Probable Error

The probable error of any measure is the measure of the limits above and below the average in which half of the individual measures are included. The probable error can also be defined as that value above and below which lie 50% of the cases. It can be found directly from S. D. by multiplying by .6745.

P. E. = O. 6745 S. D.

P. E. is the probable error.

The above is for an individual case in the series.

The reliability of an average can be indicated by the P. E. of av. which is found by multiplying the standard deviation by 0.6745 and dividing the product by the square root of the number of measurements or cases.

$$\text{P. E. av.} = \frac{\text{O. 6745 S. D.}}{\sqrt{n}}$$

Curves and Diagrams

Many psychological traits vary or distribute themselves within certain limits. A list or statement of the frequencies of each measurement is valuable but the facts can often be made more vivid by means of a visual presentation. It is good practice whenever possible to represent the results graphically.

One of the simplest types of curves is represented in the time needed for the performance of a given task, for the first trial, and after having repeated the performance.

The repetitions can be located at regular intervals along a line and the time can be located by a point directly above the point on the base line representing that trial. The distance above the line should be directly proportional to the time. A point above the line should thus be located for each trial or the average for each group of trials. Connecting the points by means of straight lines, a graphic representa-

tion of the increase or decrease of time consumed will be obtained.

This method can be used whenever two factors enter into the record. Groups of variables often appear where the mere distribution of cases is important regardless of the order in which they came. These can be shown by having various ranges of values, or quantities represented along a base line and erecting above each division a column proportional to the number of cases that fall within the range of the values or quantities of that division. Such a curve will appear as a series of rectangles standing along side each other. Sometimes the distribution comes out more clearly by joining the mid-points of each of the columns.

The number of groups represented on the base line and the distance by which each case is to be represented depends on the nature of the data and the purpose for which the graph is made.

Tables Illustrating the Use of the Above Formulae

Column (1) is the list of letters representing individuals. Column (2) is a series of measurements for the individuals. Column (3) represents the individual deviations from the average. Column (4) gives the squares for the deviations for finding S. D. The measurements are arranged in their ascending order for finding the median in column (5).

TABLE 1

(1)	(2)	(3)	(4)	(5)
A.	27	3	9	26
B.	26	4	16	26
C.	30	0	0	26
D.	26	4	16	26
E.	27	3	9	27
F.	27	3	9	27
G.	26	4	16	27
H.	28	2	4	27
I.	36	6	36	28
J.	26	4	16	30
K.	36	6	36	36
L.	27	3	9	36
M.	36	6	36	36
N.	36	6	36	36
O.	36	6	36	36
	15)450	15)60	15)284	27 Mn.
	av. 30	m.v. 4	18.93(S.D.)^2	
			4.34 S.D.	

Table II presents another series of measurements for the same subjects as table I. The calculations are given in the same order. These two tables, I and II, form the basis for the calculation of the coefficient of correlation, table III.

TABLE II

A.	12	13	169	10
B.	11	14	196	11
C.	25	0	0	12
D.	14	11	121	14
E.	17	8	64	17
F.	22	3	9	19
G.	19	6	36	22
H.	31	6	36	25
I.	33	8	64	28
J.	38	13	169	31
K.	40	15	225	33
L.	10	15	225	36
M.	28	3	9	38
N.	36	11	121	39
O.	39	14	196	40
	15)375	15)140	15)1640	25 Mn.
	av. 25	m.v. 9.33	109.33 $(S.D.)^2$	
			4.34 S.D.	

TABLE III

	X series	Y series	X deviations	Y deviations	XY
A	27	12	−3	−13	+39
B	26	11	−4	−14	+56
C	30	25	0	0	0
D	26	14	−4	−11	+44
E	27	17	−3	−8	+24
F	27	22	−3	−3	+9
G	26	19	−4	−6	+36
H	28	31	−2	+6	−12
I	36	33	+6	+8	+48
J	26	38	−4	+13	−52
K	36	40	+6	+15	+90
L	27	10	−3	−15	+45
M	36	28	+6	+3	+18
N	36	36	+6	+11	+66
O	36	39	+6	+14	+84
					$\Sigma(xy) = 495$

$$r = \frac{\Sigma(xy)}{n(S.D.)x \cdot (S.D.)y} = \frac{495}{15 \times 435 \times 10.45} = 0.72+$$

r = coefficient of correlation.

xy = product of the x deviations times the y deviations.

(S.D.)x = the standard deviations of the x series. (Table 1)

(S.D.)y = the standard deviations of the y series. (Table 2)

CHAPTER 3.

Structure of the Nervous System

Number *1.* The Skull

The head of a sheep, cat, dog or rabbit can easily be obtained. The skull can be prepared for examination as follows:— Divide the skull into halves lengthways, using a saw, chisel and sharp knife. Boil the head until the flesh becomes soft enough to be easily scraped from the bones. Soak the bones in lime water then expose them to the sun; this will bleach them. If care is taken early enough in the boiling process the bones of the ear can be saved.

Examine the prepared skull, locating everything that appears in **black.** Note the dome like **brain cavity** and by means of a human skull or pictures compare the size and shape of the brain-cavity of an animal with that of a human being. Note the position of the **eye socket** or optic orbit. Toward the back of this orbit will be found an opening, the **optic foramen,** which serves for the passage of the optic nerves and the opthalmic artery. Near the nasal margin another small opening can be found. Through this the tears flow into the nose. This opening which serves as a passage for the **lachrymal duct,** is known as the **lachrymal canal.**

Toward the back end of the skull (in the lower animals) a projecting bone is evident. In this **temporal bone** can be located the auditory

canal and its connection with the nose through the Eustachian tubes. Inside this canal in the bottle shaped bone is where the three small bones, **malleus, incus** and **stapes,** were suspended. By careful sectioning of the temporal bone the relative position of the **labyrinth** or the **internal ear** cavity can be ascertained with osseous canals for the **semi-circular canals** and the **cochlea.** Forming the roof of the mouth cavity is the **hard palate.** Above the hard palate lies the **nasal cavity** which is roofed by the **nasal bones.** The lower rear end of the nasal cavity opens into the throat.

By means of drawings and references to cuts make out as many parts of the skull as possible. This will give an idea of the relative positions of the sense organs. Often the openings for all the larger nerves can be made out. If the laboratory has some human skulls a more detailed study is useful. Get the names and positions of the various parts from any good textbook on anatomy. A knowledge of the skull and the anatomy of the nervous system are essential in any attempt to understand modern psychology.

Materials—A head or skull of some lower animal, such as as that of a dog, sheep or ox, (human skull).

2. Spinal Column

Examine a prepared speciman of the spinal

column. It consists of a series of bones called vertebrae. The vertebrae are connected by means of **articular** or joint process and the **intervertebral cartilages.** The large solid part of an individual vertebrae is called the **body.** In it will be fond the openings for various nutrient vessels. The **pedicles** project backward, one on each side from the upper part, of the body. Just back of the body above and below the pedicles are the **intervertebral notches,** two on each side which in conjunction with the notches above and below form the **intervertebral foramina.** These foramina transmit the spinal nerves and blood vessels. Two broad, flat bones complete the **vertebral arch** and close the **spinal canal.** These plates of bone are called **Laminae.** Four **Artcular Processes** project from the junction of the pedicles and laminae. A long process that projects backwards and serves for the attachment of the muscles is known as the **transverse process,** one on each side projects from the point where the articular processes join the pedicle. The vertebrae, thirty-three (human) in number, have been divided and named as follows: The first seven after leaving the skull, **cervical;** the next twelve **dorsal;** then five **lumbar;** five **sacral** and four coccygeal vertebrae. The bones of the sacral and the coccygeal region become so firmly united in the adult human that the separate vertebrae cannot be distinguished.

Consult any good anatomy.

Materials—A prepared specimen of the spinal column.

3. Comparative Study of Brains

Carefully dissect out the brain of a fish, frog, chicken, sheep, cat or other animals representing various scales of intelligence. Harden the brains by placing them in a 10% formalin solution. Make drawings of the mesial sections of the brains and note the relative sizes of the cerebrum, cerebellum and the bulb.

Materials—Heads of a fish, frog, chicken, sheep, cat or other animals, a dissecting set.

4. Brain

By cutting around a fresh skull in the shape of a cap, the top can be lifted off for an examination of the brain. Care must be taken not to saw too deep, it being best to pry off the top when most of the bone has been sawed through. The tough membrane which lies next to the boney wall of the brain cavity is the **Dura Mater.** The brain is divided into **two hemispheres** by the **falx cerebri,** a fold of the Dura Mater, dropping down like a crescent shaped curtain. An arched curtain, the **tentorium cerebelli,** covers over the lower division of the brain which in turn is divided into hemispheres by the **falx cerebelli.** Beneath the Dura Mater lies the delicate **Arachnoid** membrane. It is filled with the **cerebro-spinal fluid.** A thin vas-

cular membrane, the **Pia Mater,** with a net work of arteries and veins held together with connective tissue, follows the **convolutions** of the brain and cord. After having removed the skull-cap lift the front of the brain out slowly and carefully cutting it loose whenever necessary, or cutting the bone away by means of nippers. Work back slowly and by the help of charts and pictures locate the parts as you come to them. The **olfactory lobes** lie in grooves in the base of the cranial cavity and will be torn off if the branches that go through to the **nose cavity** are not cut from them. The two large branches of the **optic nerve** will then be encountered joining in an x shape forming the **optic chiasma.** In a little cavity lying on the floor of the cranial box will be the **pituitary body** joined to the main part of the brain by the **infundibulum.** The pituitary body will probably have to be left in its cavity. Just behind the infundibulum will be seen the double small round projecting **mamillary body.** Just back of these lie the roots of the **third cranial nerves.** (The first was cut at the olfactory lobes, the second was the optic). Turning to the right and left in a forward direction are the large fibrous masses forming the roots of the **right** and **left** hemispheres of the cerebrum called the **peduncles.** The student will now have reached the portion of the brain where it follows the cavity into a rather sharp downward turn. The **pons** forms a broad connecting band between the two sides. Out of the pons rise the double roots of the

fifth cranial nerve. At the back of the pons and just in front of the enlarged **bulb** formation, **the medulla oblongata,** lie the roots of the **sixth, seventh** and **eighth** cranial nerves in the above order from the center outward. The head of the bulb presents two slender triangular bodies running lengthwise called the **pyramids.** The **olivary bodies** lie on either side and above the pyramids. The roots of the **tenth** and **twelfth** cranial nerves rise out of the upper portion of the olivary body while the double branched roots of the **eleventh nerve** rise between the pyramids and the olive. Looking down from above the deep **longitudinal fissure** presents itself dividing the cerebrum into a **right** and **left** hemispheres. Draw the hemispheres apart and they will be found held together by a band of brilliant white fibrous tissue, the **corpus callusum.** Pull the **cerebellum,** the large double lobed part of the brain lying back under the cerebrum, forward separating it above. The thin membranous covering of the **fourth ventricle** will be visible. If the membrane is broken or showing through it can be seen the **pineal gland** held on by the **Habenula,** a rudimentary body lying in the center. Just behind the pineal gland lies the four lobed **corpora quadrugemina.** The upper portion of the corpus callosum is plainly visible. Trace it forward and downward and it narrows down into the **fornix.** The anterior stem of the fornix turns suddenly downward in front of the **optic thalami.** A mesial section of the brain will now help in get-

ting a view of the various parts. This section will show the white **corpus callosum,** with the **fornix** just beneath it, and below and behind the **thalamus.** The **space** lying under the callosum is the **third ventricle.** The narrow opening leading from the third to the fourth ventricle is the **aqueduct.** To the side of the thalamus and further forward lies the **caudate nucleus** and a part of the **striatum** or **corpus striatum.** The two prominent bodies attached to the thalamus are called the **external and internal geniculate bodies,** intimately connected with hearing and seeing.

Learn to locate and name the following fissures and gyres because of their intimate connection with brain localization of functions.

Fissure Rolando.
Supra Marginal gyre.
Angular gyre.
Post-central gyre.
Pariteo-occipital fissure.
Calcarine fissure.
Lingual gyres.
Central fissure.
Fissure of Sylvius.
Calloso-marginal fissure.
Collateral fissure.

Locate the area of the following lobes of the cerebrum: Frontal, Pariental, Occipital and Temporo-Sphenoidal.

Sections through the brain will also show

the arrangement of the **grey** and **white matter** in the cerebrum and cerebellum. For a more detailed study of the brain consult any complete textbook on anatomy.

Materials—The head of a sheep or other animal, dissecting instruments, charts and pictures of the brain.

5. Spinal Cord

The spinal cord can be studied by dissecting it from a cat, dog or sheep. The **bulb** of the brain becomes smaller and passes out of the **foramen magnum** into the **spinal canal** as the **spinal cord.** Coming out in front and behind there will appear groups of nerves joining each other on either side of the spinal column in the form of ganglia. Cutting across the spinal column and cord the same coverings can be distinguished as found around the brain. **Dura Mater, arachnoid, Pia Mater,** in the above order coming from the outside in. Leaving toward the back or dorsal portion of the cord are the **sensory nerves** with their cell bodies lying outside the cord.

The motor nerves leave toward the front or ventral side of the cord. A cross section of the cord further reveals a dip or fold of the Pia Mater almost cutting it in two from front to back, the **anterior** and **posterior median fissures.** Lying on either side of these fissures two minor fissures can be observed, called the **posterior**

lateral fissures and the **anterior lateral fissures.** These fissures divide the cord into the **anterior, lateral** and **posterior columns.** The **grey matter** of the cord lies roughly in the shape of a letter H with the large portion lying to the front called the **anterior horn.** The narrowed portion lying toward the back is called the **posterior horn.** The **grey commissure** is the band of grey matter that connects the two sides of the H shape mass. The grey matter is surrounded by white fibrous matter. The relative amount of grey and white matter differs in various portions of the cord.

Materials—Specimens of the spinal cord, dissecting instruments.

CHAPTER 4.

Cutaneous Sensations

6. Cold Spots

The experimenter should explore various portions of the back of the hand of the subject to gain a general idea of the nature of the cold spots. Take some round pointed metallic object that feels cold and touch lightly various points on the skin. Note the characteristic flash of cold when one of the cold spots is touched. The subjects should not see the exploration during the experiment, but either close or turn away the eyes. The experimenter now proceeds to map an area of 20 mm. square. Immerse a metal cylinder in ice water or expose it to a freezing temperature. After the cylinder has been thoroughly cooled, dry it and explore the charted area carefully. The exploration should be done in a systematic manner, running along imaginary, parallel lines about 1 mm. apart. When the subject exclaims that he feels a pronounced cold sensation, come back to the spot from various directions, thus locating it as accurately as possible. Mark this position with ink, dye or water-color. The marking may be done with a finely pointed brush, or a small tooth-pick. Keep the cylinder cool. After the marked area has been thoroughly explored, place a piece of tracing paper on the skin and copy the marked cold spots in their proper positions.

Materials—Pointed metallic cylinder (Figure 1), pen or tooth picks, inks or dyes, ice, tracing paper.

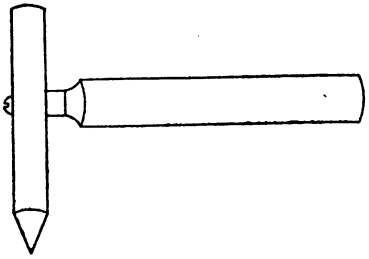


Figure 1. Metallic Cylinder for Temperature Sense Exploration.

7. Hot Spots

Warm the same cylinder, as was used in searching for the cold spots, to a temperature (48°C) that can be tolerated without unpleasantness. Make a few preliminary explorations to gain an idea of the sensation when a hot spot is stimulated. Mark off the same area that was used for the cold spots. Explore it in the same way, marking the hot spot with a different color from the cold spots. Do not allow the cylinder to rest too long on a hot spot for they may become fatigued and fail to respond. For the same reason explorations for verifications should not be attempted too soon after the spot has been located.

If possible both the hot and cold spots should be marked on the same chart in different colors. Comparisons are then easily made as to their relative number, position, etc.

Report as to the definiteness of the spot and indicate by color or characteristic mark the relative intensity of the warm sensation.

Materials—Pointed metallic cylinder (Fig. 1), thermometer, pen or sharp tooth picks, inks or dyes, tracing paper, Bunsen burner, pan for heating water.

8. Touch or Pressure Spots

Mount hairs or thin bristles of different lengths and thicknesses on convenient holders or match-sticks by means of glue or sealing wax. (Fig. 2). The various lengths and thicknesses will permit the exertion of various pressures before bending. The amount of these pressures can be measured in grains by applying the end of the hair to one of the pans of a balance.

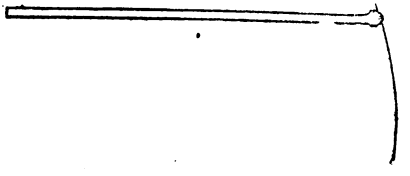


Fig. 2. Hair Mounted for Touch Spot Exploration.

All hairs growing out of the skin have a touch spot underlying them, they therefore should be carefully cut off and their point of emergence marked. Select a mounted hair of such a length and thickness that the pressure

exerted is very light. Carefully explore an area of from 10 to 20 mm. square. Mark the points where the pressure is felt. Select two more hairs with increasing pressures such that the pressure of the heavier one is somewhat less than what could be felt over the entire area. Mark in a different color the additional pressure spots found with each of these hairs. Transfer these marks to a chart noting the original hair follicles by some characteristic mark. Observe the different kind of sensations as touch endings of varying sensitivity are stimulated. Are there other sensations than that of pressure? Are the pressure spots located with an equal degree of accuracy?

Materials—Stiff hairs or bristles, match sticks, wax, scale weighing in grains, pen, pointed tooth picks, inks or dyes, small scissors, transfer paper.

9. Pain Spots

Close the hand thus stretching the skin rather tightly over the knuckles. Touch the bent knuckles lightly with a finely pointed object, like a needle, better still a fine thorn. Can you distinguish pain endings from touch sensations, or does the pain sensation follow that of touch? Describe the sensation. Show the number of pain endings either by chart or counting them within a bounded area around the knuckles.

Materials—Fine needle or thorn, pen or fine pointed tooth picks, ink, tracing paper.

10. Charting Pain Spots

Bound a small hairless area on the back of the hand. Try to locate the pain endings. The skin may be made more sensitive by softening it with warm water. Thorns mounted on thin

Fig. 3. Thorn Mounted for Pain Spot Exploration.

bamboo strips (Fig. 3) are excellent for this work as they do not give temperature sensations. The thin bamboo strips spring back and avoid puncturing the skin which is very important. Pointed hairs or bristles can also be standardized and used. A chart can be made in the same manner as for the cold and hot spots.

Materials—Mounted thorns, pen or finely pointed tooth picks, ink, tracing paper.

11. Temperature Adaptation

Place the finger of one hand in water at 15 C (59 F) and the same finger of the other hand in water considerably warmer, say 35 C (81 F). Take note of the initial sensations then the gradual adjustment. After the adaptation seems complete transfer both fingers into the

same water at approximately 25 C (77 F). Describe the sensation arising from each finger.

Materials—Bunsen burner, pans, thermometer.

12. Temperature After Images

Place a cold coin on the forehead or on the palm of the hand. Leave it there for 30 or 40 seconds. Remove it and note the after sensations. Are they like the stimulus? Are they uniform? Note the time of the after-sensation. Place the coin on the forehead for one minute; noting the above points; two minutes; three minutes; four minutes; and five minutes.

Materials—Coin, watch.

13. Application of Touch, Prick and Electrical Stimulations on Cold and Hot Spots

Select a very sensitive cold spot and apply a heat stimulation. What results do you obtain? In the same way select a hot spot and apply a freshly cooled cylinder, noting the results. Stimulate both the sensitive hot and cold spots by lightly tapping them with a small pointed object or bristle. Select two other hot and cold spots into which thrust a thin, finely pointed needle. Try also the effect of stimulating these spots by means of a weak interrupted electrical current.

Materials—Pointed metallic cylinder, Bun-

sen burner, ice, pointed tooth picks, interrupted electrical current.

14. Pressure Experiment

Dip the hand and part of the fore-arm into a rather deep vessel of temperate water. Where is the pressure of the water most distinct? What explanation can you give for the result?

Materials—Deep vessel for water.

15. Pain and Touch Spots

Stimulate a touch or pressure spot simultaneously with a pain spot. Compare this sensation to the sensation produced by brushing the tip of the nose lightly by means of a soft brush or feather.

16. Pain Endings Inside the Cheek

Explore the inside of the cheek for pain endings by means of an interrupted current. How do you account for the large painless area?

17. Pain and Temperature Sense

Dip the hand into water heated to 50 C (122 F) and note the sensation. Is the temperature sense still present when the stimulus takes on a painful quality?

18. Relation of Extent to Intensity of Thermal Sensation

Dip the entire hand into water at 25 C (77

F) and at the same time dip one finger of the other hand into water at the same temperature, add cold water as required to one of the vessels till the temperature of the water that is being tested by the finger seems the same as that of the hand. Note the difference in degrees.

Materials—Vessels for water, thermometer.

19. Pain Threshold

With a pressure scale having a head of known size, press upon some part of the body with a slow uniformly increasing pressure until

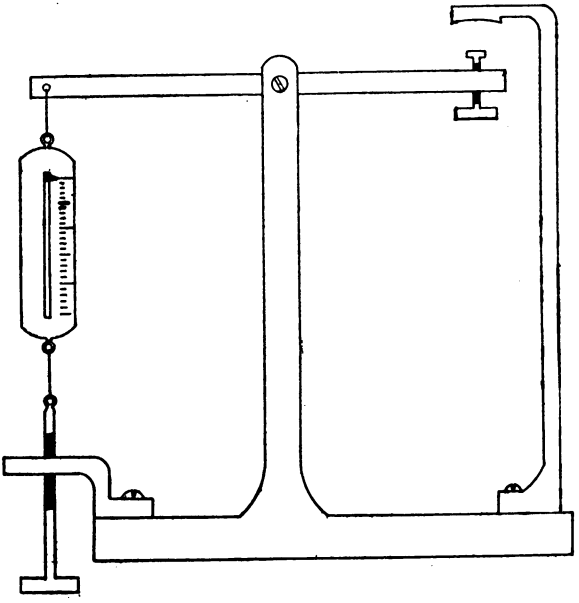


Fig. 4. Pressure Pain Balance.

the subject indicates a feeling of unpleasantness or beginning pain (not how much he can stand). Read the scale at the moment the report is made, recording the size of the surface applied and the pressure. Compare the results of the pain threshold of other parts of the body. Apply a larger surface to the body and note the results.

Materials—A pressure scale, pressure-pain balance or algometer. (See Fig. 4).

20. Touch Discrimination of Two Points.

To measure the tactual discrimination of two points use a pair of compasses tipped with rounded points of rubber or hardwood. A good substitute for the compasses can be made by pushing round hard tooth picks through strips of card-board. Measure the distances that the points are apart on a mm. scale. The subject should not watch the experiment, nor should he know the results until the whole experiment has been performed. Select some surface on the fore-arm that is comparatively free from hair and separate the points far enough apart so they can easily be distinguished as two. With as uniform pressure as possible apply the points to the surface selected, sometimes 1 point, sometimes two, in an irregular order. Ask the subject to report the number of points that have touched him. Take at least 10 reports for two points at a given distance. Reduce the distance

between the points and repeat the trials. When one point is presented it should always be reported correctly, but under certain limits two points will seem as one. Keep reducing the distance between the points until they seem as one. Then increase the distance by a millimeter for each 10 applications of two points until no errors occur. In the form of a table, record the space between the compass points, the number of points applied, the number of points reported by the subject, the number of two-points correctly recognized. Repeat this experiment for other parts of the body, not omitting the back of the neck. Compare the results.

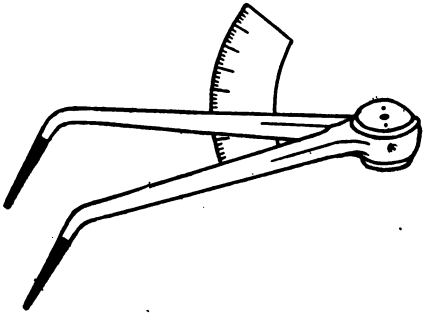


Fig. 5. Compass with Scale.

Materials—Compass (Fig. 5), millimeter measure.

21. Discrimination of a Point from a Line

From a piece of thin, stiff card board cut a series of oblongs; ½ mm., 1 mm., 1½ mm., 2 mm., 2½ mm., 3 mm., 3½ mm., 4 mm., 4½mm.

and 5 mm. wide. By pressing the end of the narrawest strip against the back of the hand it will be felt as a point. Press each width to the back of the hand ten times, interspersing it occasionally with the ½ mm. strip. Have the subject report as to whether it feels as a line or a point. Use wider and wider strips until there are no mistakes as to its being a line. Then repeat with narrower strips until they all feel like points. In a table show the width of the strip used, the replies and correct recognitions. From these reports, establish the shortest line that can be recognized as such. Try other parts of the body in the same manner. Compare the results with those for the recognition of two points.

Materials—Thin, stiff card board, millimeter measure.

22. Apparent Distances on the Cheek

Take a compass and set its points 2 cm. apart. Draw the points at a uniform rate and pressure from the subject's ear to his lips. Report the apparent distances between the points and the apparent rate at various places.

Materials—Compass.

23. Judgment of Distance Around the Lips

Separate the points of a compass so they can be drawn from one corner of the mouth to the other with the points passing along the outside of the margin of the lips. Keep the dis-

tances between the points constant. Report the apparent distances at various places.

Materials—Compass.

24. Aristotle's Illusion

Place the hand on a table, palm upward. Have the subject close his eyes while the experimenter crosses two of the subject's fingers. Touch the adjacent sides of the crossed finger tips with a single small round object. Does it seem like one or two objects to the subject? Touch the outsides of the crossed tips with two similar objects and get a report of the number that seem to be felt. Take a compass and lay the two fingers down side by side and touch the tips with the points separated various distances; on outlines have the subject put dots representing the position of the points. Now hold the fingers crossed and repeat the experiment. Prepare a series of small, simple geometrical figures, small enough so they can easily be felt by the tips of two fingers lying side by side. Prick a pin from the back side through the intersections of every line. Feel the pin pricks with the tips of two fingers in their normal position and reproduce the pin pricks with dots on another sheet of paper. Repeat the same experiment with the fingers crossed. Some fail to get the illusions because they visualize the crossed fingers and correct the tactual impression. In order to get the most striking results depend as much as possible on the tactual image.

Materials—Pencil or any other small round object, compass.

25. Absolute Touch Localization

Draw a full size outline of the flexor surface of the subject's left fore-arm, filling in the veins, tendons and other land marks. Give the subject a blunt-pointed pencil to hold in his right hand, hanging at his side. The experimenter should touch the subject's fore-arm with a similar blunt pencil, pressing gently on the point for two seconds. Remove this pencil and have the subject (blindfolded or looking away) place his pencil on as near the same spot as possible. On the sketch record the locations of the original spot touched, the point indicated by the subject, the direction and amount of error.

Repeat the experiment for various parts of the fore-arm and other parts of the body. Take care to keep the duration of the touch, amount of pressure and time between touches approximately constant.

Materials—Blunt pointed pencils, life size charts.

CHAPTER 5.

Gustatory Sensations

26. Nature of Substance Tasted

Wipe the tongue dry with a clean cloth or absorbent cotton. See if pinches of salt, sugar and powdered marble can be distinguished. Allow the tongue to be covered with saliva so as to dissolve part of the powders. Can they be tasted now?

Materials—Dry salt, sugar, marble dust, absorbent cotton.

27. Gustatory Acuity

Prepare taste solutions of various substances, such as sugar, salt, vinegar, quinine, etc. Strong enough to make the taste easily detected. Place a teaspoonful of one of the solutions (the kind should not be known to the subject) in the mouth and let it touch all parts of the tongue. Have the subject try to identify the solution from the names of the substances in the solutions that could easily be tasted. After the subject has examined the solution he should rinse his mouth thoroughly with distilled water. Reduce the strength of the solutions until the subject fails to detect their taste, keeping a record of the percentage of taste material in the solution. This experiment can be repeated beginning with subliminal so-

lutions and gradually increasing their strength until the taste becomes plainly apparent.

Materials—Sugar, salt, vinegar, quinine, scales, graduated glass.

28. Reactions of Individual Taste Papillae

Draw an outline of the tongue, marking the contour and median lines, and putting in a few easily recognizable groups of papillae, preferably in different locations. From these groups select five easily recognizable prominent papillae to be used for the experiment. Prepare 40% sugar, saturated salt, 8% tartaric acid and 2% quinine solutions. Place these solutions into bottles of like appearance. Add also a bottle of distilled water. Have a large bottle filled with tasteless water in which the brushes can be washed. Have water ready with which to wash the mouth and a receptacle for the rinsings. Take a small pointed camel's hair brush, rinse it in the water, then dry it with cotton. Dip the brush in one of the solutions. The subject at a signal from the experimenter dries his tongue as much as possible against the roof of his mouth. The tongue is then extended and the experimenter quickly dries the papillae to be used by means of a tuft of cotton. The brush is then carefully applied to the papillae, care being taken not to touch the surrounding area. Hold the brush in place about two seconds when the subject can withdraw his togue and make a report. After a few minutes' rest another pa-

pilla can be stimulated, either with the same or another solution; and so on, until all five have been stimulated. Allow a rest period of a few minutes then repeat the expirement, stimulating the papillae in a different chance order.

Stimulate occasionally with distilled water to see that the subject is not merely guessing. Continue until each papilla has been stimulated five times by each of the four solutions. Can the same papilla taste the different solutions? Are confusions common and do they appear with equal frequency for all papillae? Explain results as fully as possible.

Materials—Small pointed camel's hair brush, sugar, salt, tartaric acid, quinine, scales, graduated glass.

Note—A splendid substitute for the small brushes can be made by winding a bit of cotton around the point of a sharp toothpick. These can be discarded after they have once been used.

29. Weak Taste

Experiment with the taste solutions after they have been weakened to 20% sugar, 2% salt, .5% tartaric acid, .002% quinine.

Record the results with a statement of their clearness, intensity, etc.

Materials—Sugar, salt, tartaric acid, quinine, means for measuring.

30. Effect of Cocaine on the Taste Papillae

Paint a papilla with cocaine and repeat the taste tests. Do not allow the cocaine solution to spread over the surrounding area of the tongue.

Materials—Cocaine solution, small brush, taste solutions.

31. Detection of Various Tastes

Repeat the stimulation of the papillae with ten different taste solutions and analyze the method of recognizing them. Stop the nostrils with tufts of cotton so as to judge by tastes only and not by odors.

Materials—Various taste solutions.

32. Simultaneous Taste Contrast

Dry the subject's tongue and apply to one side of it a taste solution, the nature of which the subject is ignorant. The solution must be so weak that the end organs are not stimulated. The strength of these solutions can be tried out experimentally to see if they produce sensations.

The subject should have his eyes closed and nostrils stopped. Drop by means of pipettes a drop or two very weak solution of salt on one side of the tongue and on the other a standard (See Exp. 28) solution of sugar. Take care that the solution does not cross the median of the

tongue. Rinse the mouth of the subject and apply the standard sugar to the side of the tongue on which the weak salt was applied before. Repeat the experiment, using water in place of the weaker solution. Try also a weak solution that is not subliminal.

In the same manner use a weak solution of sugar with a standard solution of salt.

Materials—Solutions of sugar and salt, pipettes.

33. Successive Taste Contrast

Apply a standard (See Exp. 28) solution to the tip of the tongue. After two or three seconds rinse the mouth and apply distilled water. Repeat the experiment using instead of the distilled water various weaker solutions of the same taste and of other tastes. Try especially various sugar and salt solutions.

Materials—Solutions of sugar, salt, tartaric acid, vinegar, quinine.

CHAPTER 6.

Olfactory Sensations

34. Olfactory Acuity

Dissolve a gram of camphor gum in 1,000 cc. of odorless water. Prepare from this solutions of the following strengths: 1:2000, 1:4000, 1:8000, 1:16,000, 1:32,000. Place samples of the various solutions in clean test tubes. In tubes of the same size and shape leave samples of pure water. Mark the tubes in such a way that the experimenter can easily identify them but so the subject cannot. Place the tubes in a rack which holds them in a row not too near together. The subject smells of each tube in turn reporting "water or "camphor." Allow considerable time to escape between sniffs and sniff only once at each tube as olfactory fatigue easily sets in. The experimenter can report the strength of solutions for which no errors are made, those for which some errors were made and those always classified as water. The threshold can thus be established.

Other odors can also be used and their threshold established. Care must be taken to avoid the room being filled with the odors.

Materials—Camphor gum, distilled water, graduated measure.

35. Classification of Odors

Zwardemaker's modification of Linnaeus' tables is as follows:

1. Etherial; including fruit odors.
2. Aromatic; camphor, spice.
3. Fragrant; many flowers, violets, sweet peas, etc.
4. Ambrosiac; musk.
5. Alliaceous; garlic, chlorine.
6. Empyreumatic; burning tobacco, toast, coffee.
7. Hircine; cheese.
8. Virulent; opium.
9. Nauseous; decaying animal matter.

Above are given as the names of odors with examples for each, supposed to be typical. Get as large a variety of odors as possible and try to classify them according to the above table. Compare your classification with as many others as possible.

Materials—Various substances that emit odors.

36. Olfactory Fatigue

Take four or five odors of different character and become familiar with their apparent strength. Plug one nostril with cotton and inhale one of the odors (eyes closed) until it seems to disappear. The experimenter should then hand him other odors to be examined. What can be said of their relative strength with the first time they were examined? After an interval of several minutes try the original odors again, then fatigue the organs of smell

with a different odor noting the effect on the rest as before.

Materials—Odor solutions.

37. Odor Mixing

From a large collection of odors select two in small bottles and pass them rapidly back and forth before the subject's nostrils while he is inhaling slowly. Is the odor from the two a mixture or does one predominate, or does one appear at times to be followed by the other. Continue the experiment with other odors. Try the experiment by holding one odor to one nostril and the second one to the other nostril.

Materials—Odors.

CHAPTER 7.

Labarynthine Sensations

38. Labarynthine Sensations and Movement

Place the subject on a platform that can be rotated in the horizontal plane. The subject should be perfectly still with his eyes closed. Rotate him gently and steadily. Does the subject feel that he is being rotated. Increase the speed rather suddenly and it can be noticed by the subject. The subject should move his head and notice the effect of the rotation. Stop the rotation and get the subject's sense of movement.

Materials—Rotating platform.

39. Labarynthine Sensations and Eye Movement

Repeat the same experiment with the eyes open and notice the eye movement of the subject as much as you can. Have him give a full report of his feeling, method of accommodation, etc.

Materials—Rotating platform.

40. Sense of Vertical Position

Strap the subject securely on a table that turns over in a vertical plane. The subject, with his eyes closed should be turned over two or three times. He then is asked to tell when his

head is straight down and up without looking. The experimenter should record the position at which the report is made and measure the number of degrees of error. Repeat the experiment turning the subject over in the opposite direction.

Materials—Vertical rotating platform.

CHAPTER 8.

Auditory Sensations

41. Auditory Acuity

Go into a quiet room (at night or in a sound proof room) and take a watch that has just been wound or a fall hammer acoumeter for a source of sound. Warn the subject that at times the sound will be audible and at times inaudible. If a watch is used it can be held in the closed hand to make it inaudible. Give the subject warning and then ask him to report when he hears the sound and when he fails to hear it. See that the source of sound, when audible, is in the same position and has in every way the same efficiency. Select a distance from the subject such that the sound is plainly audible, then re-

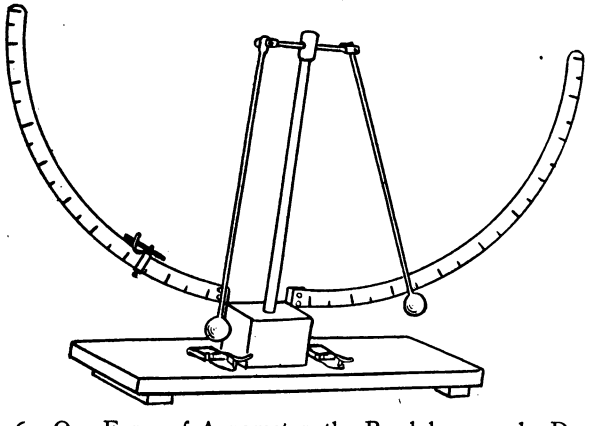


Fig. 6. One Form of Acnometer, the Pendulum can be Dropped from Various Heights for Different Intensities.

treat a given distance, each time repeating the experiment. When the subject fails to distinguish between the audible and inaudible periods his limit of auditory acuity has been reached.

Repeat the experiment, going beyond the limit of hearing and approaching the subject. Average the results of the two distances. Test one ear at a time, stopping the other one lightly with cotton.

Materials—Watch, acoumeter, (Fig. 5). tape measure, sound proof room.

42. Auditory Adaptation

Place the ends of a rubber tube in each ear.

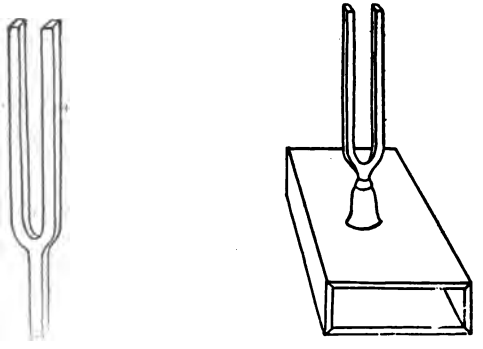


Fig. 7. Tuning Forks, Unmounted and Mounted on a Resonating Box.

Carry the tube back of the subject's head and support it on a table or platform. Rest a vi-

brating tuning fork gently on the tube directly back of the head. Compress the tube so the sound travels only to one ear. As soon as the subject reports that the sound is no longer audible, release the tube and open both paths to the ear. What is the result?

Materials—Rubber tube, tuning fork.

43. Sound Conduction

Apply the foot of a vibrating tuning fork to the top of the head or to the teeth. Let the fork die down so it cannot be heard, then repeat the above. Another good place to make the fork seem highly audible is on the prominent bone behind the ear (Mastoid Process). Why should the sound seem so plain? What conducts it to the inner ear?

Materials—Tuning fork.

44. Nature of Resonance

Sound a tuning fork without its box. Allow

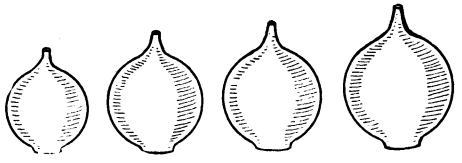


Fig. 8. Resonating Spheres. The small end is placed in the ear and the vibrating body is held before the large end.

the tone to die down until it is impossible to hear. Place this fork on its resonator quickly;

does it make it audible? Will the intensity be as great over all resonators?

Materials—Tuning fork, resonators.

45. Aural Resonance

Hold a vibrating tuning fork before the ear, listen to it dying down until it is impossible to hear it, then insert your finger **gently** into the opposite ear, or introduce a ball of cotton. Does the sound increase or decrease? Explain the result.

Materials—Tuning fork.

46. Ear as a Resonator

Sound several tones in the vicinity of **fIV.** Often a tone can be discovered that seems to have a piercing character. Determine the pitch of this tone. The resonating quality of the external meatus may be altered by inserting a piece of rubber tubing about one inch long in each ear. Note the difference in quality of sounds heard. What tones does it modify most?

Materials—Tuning fork, musical instruments, small rubber tubing.

47. Measuring Wave Length by Resonance

Sound a tuning fork over a tall vessel that is of uniform size throughout. Keep filling the vessel with a little water at a time until the increased intensity, due to resonance, has

reached its maximum. Measure the distance from the fork to the water. If the vessel is tall enough fill until a second and third points of intensity are found. Measure the distance carefully in each instance. What relation does the wave length bear to the size of the resonating cavity?

Materials—Tuning forks, tall cylindrical vessels for holding water.

48. Nature of Overtones

Pluck the string of a monochord. Touch the vibrating string in the middle with a feather, a narrow twisted tuft of cotton, or strip of paper. Listen carefully for the higher pitched tone produced. What is the pitch of this tone? Trisect the string in the same manner as above. What is the pitch of the tone produced? Can you hear these over-tones without using the brush?

Materials—Monochord.

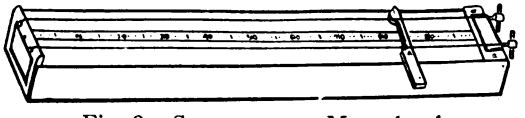


Fig. 9. Sonometer or Monochord.

49. Timbre

Sound several musical instruments of the same pitch so the subject cannot see them. Can the subject distinguish one from the other? If one is resounded does the subject identify it?

Analyze the qualities of the sounds that make possible this identification. By means of resonators pick out the important over-tones.

Materials—Musical instruments, resonators, (Fig. 8).

50. Discrimination of Pitch

Sound a tone of a certain pitch, then sound another slightly higher or lower and ask the subject to state whether the pitch is higher or lower. The subject should be seated about 1 meter from the source of the sound and have his eyes closed. Take ten judgments for each pitch difference, giving the higher one first at times and last at times. Gradually increase the difference in pitch until no errors are made. If tuning forks are used record the vibration rates of each pair, and the judgments, if some other source of sound is used, calculate the vibration rates.

Strike the forks with blows of about the same intensity with a soft-tipped hammer. The forks should be mounted on their resonators. Damp the vibrations of the one fork completely before the second one is struck.

Materials—Tuning forks (Standard 426⅔ vibrations), comparison forks whose vibration rates are 1, 2, 3, 4, 5, 8, 12, 17, 23 and 30 vibrations below standard.

51. Tone Character

Select tones of various pitch from the high to the low, or low to the high, and describe them in words other than high and low. Describe them as heavy, light, piercing, dull, etc.

Sound each tone continuously and, with eyes closed, give the first associations brought to mind. Can they be characterized by words representing feelings such as gay, sad, lively, etc.?

Materials—A series of tuning forks on their resonators.

52. Intensity of Tones

Sound a high and low fork simultaneously on their respective resonance boxes. Let them die down until the high-pitched fork can no longer be heard. Stop the low fork. Can the high fork be heard again? Reverse the process, does it revive the low fork? What is the nature of a tone in regard to pitch that will overcome another tone?

Materials—Tuning forks on their resonators.

53. Upper Limit of Pitch

Use a Galton Whistle for this experiment. Care should be taken to have the wind pressure uniform. The subject should seat himself in a comfortable position in a quiet room. Avoid shifting or moving about. The experimenter holds the whistle about three feet away from

the ear of the subject. Set it so as to produce a distinctly audible tone. After each blast shorten the whistle until only a puff of air is heard. Record the length of the gap when the tone has just disappeared. Shorten it a bit more so that the tone is not audible, then lengthen the whistle gap until the tone is just audible and again record the length. Get a record of ten measurements going each way for your result.

Materials—Galton, or Galton-Edlemann whistle.

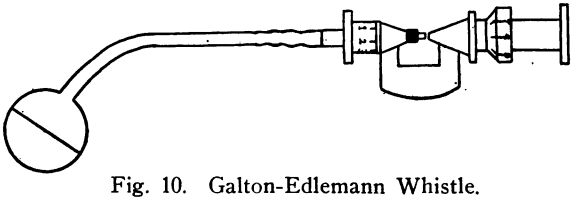


Fig. 10. Galton-Edlemann Whistle.

54. Lower Limit of Pitch

Take a series of tuning forks that range from 10 to 40 vibrations per second. Sound them close to the ear of the subject, beginning with the lowest, and note the fork of which the vibrations seem to blend into a tone. In the same manner begin with the fork vibrating at 48 per second and take up those that vibrate slower until one is found that ceases to give a distinct tone. Is a tone clearly distinguishable from repeated puffs of air?

Materials—Slow vibrating forks.

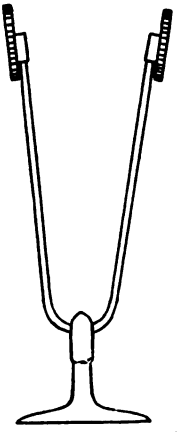


Fig. 11. Slow Vibrating Tuning Fork.

55. Auditory After Sensations

Suddenly stop the vibrations of a tuning fork while it is being held before the ear of the subject. Do you get an after sensation? What is its nature, duration, qualities?

Materials—Tuning fork.

56. Beats

Take two forks of the same pitch and weight one with a clamp so its vibration rate is reduced slightly. Have each fork mounted on its resonator. Sound them simultaneously. If there is very little difference in their vibration rate, the beats per second can be counted directly. If the weight on the fork is increased or placed

nearer the free end, what results? If the beating rate is increased it becomes a tone of very low pitch. Can you detect this tone?

Materials—Two tuning forks of the same pitch, weighting clamps.

CHAPTER 9.

Visual Sensations

57. Purkinje's Images

In a dark room have the subject turn his eyes toward a light colored plain wall so as to expose as much of the white of one eye as possible. By means of a reading glass or any double convex lens focus the light of a candle on the white sclerotic coat. A shadow picture of the blood vessels of the retina will be visible.

Materials—Dark room with light walls, lens, candle.

58. The Blind Spot

Place a small cross or x on a sheet of paper and about 7 or 8 cm. to the right of it place a heavy circle, 1.5 cm. in diameter. Close the left eye, look at the cross, then move the sheet of paper back and forth, rotating it slightly and it will be found that at a certain point the circle will disappear. The image of the circle has fallen on the Blind Spot. To find the blind spot of the left eye invert the paper, placing the circle to the left of the cross.

Materials—Sheet of paper with the proper designs upon it.

59. Visual Adaptation

Go from the sunshine to a darkened room

and note the time required to adapt yourself to the reduced illumination. Sit for a time in a dark room, then suddenly turn on a strong light, simultaneously starting a stop-watch; stop the watch when your vision has reached its greatest efficiency for that illumination. If possible, by means of a photometer, standardize the illumination in terms of candle power.

Materials—Stop-watch, dark room, photometer.

60. Visual Acuity

The visual acuity of an individual can best be tested by the use of a special chart, prepared for that purpose. Test one eye at a time, trying all the characters or letters in the line. Proceed from the larger to the smaller characters until a line is reached in which mistakes are made. Move nearer and repeat the experiment. The subject, of course, will then be able to read smaller characters. The visual acuity is denoted by a fraction of which the numerator represents the distance at which the letters could just be read, and the denominator represents the distance at which they should be read, as indicated on the test chart. In "normal" acuity the numerator and denominator have the same value. Bright daylight without direct sunshine is usually considered the standard light. For comparisons care must be taken to have the light uniform. Note any differences

of the mental attitude as the experiment proceeds. This experiment has many practical applications. Discuss them.

Materials—Visual acuity test charts.

61. Discrimination of Brightness of Transmitted Light

Arrange a box so the light from an electric lamp shines through two translucent windows, by means of reflecting the light with white screens. Record the angle of the screens as these become the basis for calculating the brightness of the window. Get the maximal illumination for the windows and record the just discriminal setting of the levers that can be discerned. Use first one and then the other window as the standard. Arrange a head rest so that the subject can hold his eyes directly in front of the apparatus on a level with the windows.

Study the effect of practice. Substitute colored lights for the white one.

Materials—Box, arranged with reflecting mirrors, frosted lamp bulb and glass windows.

62. Visual Difference Threshold

Mount a large white disc with a radial slit on a color mixer. Through this slit introduce a smaller colored disc, also slit along a radius. A screen should be set in front of the color mixer

when the discs are being mounted and when changes are made so that the subject never sees the discs except when they are rotating. Increase the amount of color projecting through until the color is noticed and named by the subject. Increase the amount of color until it is plainly visible, then gradually decrease it until the subject reports its disappearance.

Record the amount of color actually present each time in per cents of the total circumference or in degrees.

Repeat this experiment with black, grey and colored discs.

Materials—Rotator, discs.

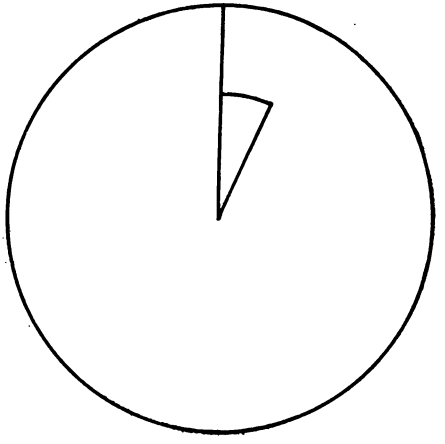


Fig. 12. Showing method of introducing smaller disc.

63. Test for Color Blindness

The Holmgreen worsted yarns are usually used to test for color blindness. Take the three large test skeins (pale green, red, rose, Nos. 101, 102, 103) from the rest. Scatter the small skeins over a grey or white background. Give the subject the large pale green skein and direct him to select all the skeins that resemble the standard in **color,** including all the shades and tints of that color. No two skeins are alike, and an exact match is not required. If the subject includes some grays, browns or reds in his selection, repeat the test with red and rose standards.

Keep an accurate record of the skeins selected as having in them the same color as the standard. The color-blind will include uncolored and shades and tints of other colors with the standard. Avoid the naming of the colors during the test except by way of illustration.

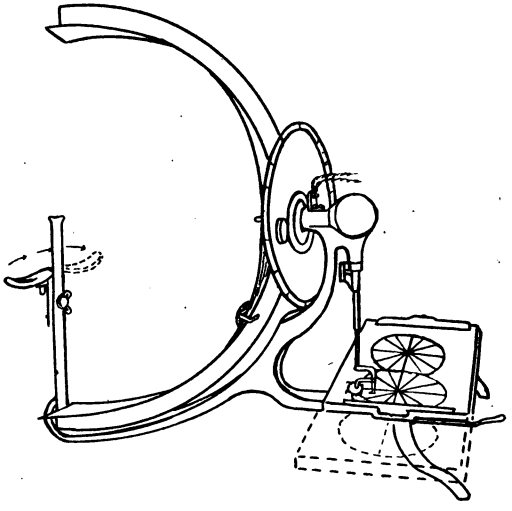
Materials—Holmgreen's worsteds, light grey or white cardboard for a background.

64. To Find Original Colors by Means of Peripheral Vision

Use purple, violet, green, red, blue, yellow and one or two other colors in this experiment. Fixate on a white spot and by means of a campimeter cause the small colored spot or disc to be exposed on all portions of the retina from the

center to the outside margin in a straight line in any direction (up, down, right, left). Note how the colors disappear. Do all the discs suddenly change to a grey or do they take on a color value intermediate between the original color and the grey? Do all colors change to grey before disappearing? Explain results.

Materials—Campimeter or perimeter, small colored papers.



13. Perimeter or Campimeter.

65. Charting the Color Areas of the Retina

From the former experiment select those four colors that did not change their color value

before becoming grey and use them in this experiment. Fixate on the white spot and by means of the campimeter cause the colored spot to be thrown on all points of the retina from the center out, the same as in the former experiment. At the moment the color disappears stop the movement and note the number of degrees from the center at which you stopped. Then move the spot out beyond this point and take the reading at which the color appears in coming back. Take ten of these readings for each position of the campimeter wing (five in each direction). Record readings for at least four positions of the campimeter wing (up, down, right, left) and as many more as time will permit. Average each ten readings. Make a chart by locating points at such distances and directions from a center as shown by the averages of each color in its direction. Connect these points with lines of the same color as the disc used in making the record.

What can be said of the relative size of the fields of the retina that are sensitive to each of the respective colors? How does the relative size of these fields and the colors they represent compare with the order in which color blindness sets in? What suggestion does this experiment give in regard to evolution of color sensitivity?

Materials—Campimeter or perimeter, colored papers, retinal charts.

Note: On some campimeters it may be necessary to reverse the recorded readings in direction for the chart. Note the direction of the readings and the direction the colored spot travels from the fovea of the eye and it will soon appear whether the readings should be direct or reversed to be true for the subject's retina.

66. Effect of Distance on Apparent Brightness

Place a white disc on a color mixer, 5 to 10 feet away from the subject. Place a sheet of the same paper 30 feet or more away, so situated that it can be seen past the edge of the disc. Take a tube with an opening in it so small that nothing but portions of the near disc and the farther sheet are visible at once. It will be seen that the white farthest removed seems darker. Introduce black with the white disc until it seems to match the sheet 30 feet away. Record several trials in the following form:

W----% + Bla----% at----feet=W 100 % at----feet.

Materials—Rotator, white disc, sheet of paper of the same whiteness as the disc, measuring tape, tube, measuring disc.

67. Brightness and Intensity

Match a black and white mixture in brightness equivalent to various samples of colored paper. Take a series of four or five colored papers and try to get the same brightness by a

mixture of black and white. Use your best judgment. Which seems the brighter, blue or yellow? Red or green? Record equations.

R100% = Bla____% + W____% etc. in intensity of brightness.

Materials—Colored papers, rotator, black discs, white discs, measuring disc.

68. Perception of Colors

On a white or better a grey background 30 c. m. square mount 100 small squares of colored paper. The colored papers should be 1½ c. m. square and so arranged that they are 1½ c. m. apart in each direction. Use ten colors:—black, blue, brown, green, grey, orange, pink, purple, red, yellow. Have each color appear 10 times on the card, arranged in a chance order with no two squares of the same color appearing in succession in either direction.

Have the subject read the colors over several times in order to familiarize himself with their names.

To conduct the experiment, have the subject lay the card before him, colors down. Then upon a signal from the experimenter the subject turns the card up and names aloud the colors as rapidly as he can. The experimenter follows him and in case any color is incorrectly named, says "no." The subject is required to give the correct name before proceeding. A record is

kept of the time required to correctly name the 100 colors. The card can be rotated ¼ of the way around for each successive experiment, thus eliminating memory effects.

Materials—Colors mounted on a card board according to the directions given above.

69. Positive After Image

The rapid movement of a stick to and fro causes it to spread out in a fan-like shape. Where is this image most prominent, near the stick or farther away? Mount a white disc

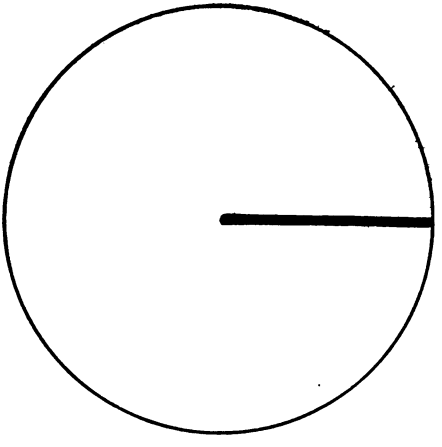


Fig. 14. Disc arranged to show positive afterimage.

with a heavy black line along a radius, on the color mixer and slowly increase the speed of rotation until the line just spreads over the disc, showing no flicker. Get the number of rotations per second. From this data calculate the duration of the positive after-image.

Materials—Rotator, white disc, speed indicator, watch.

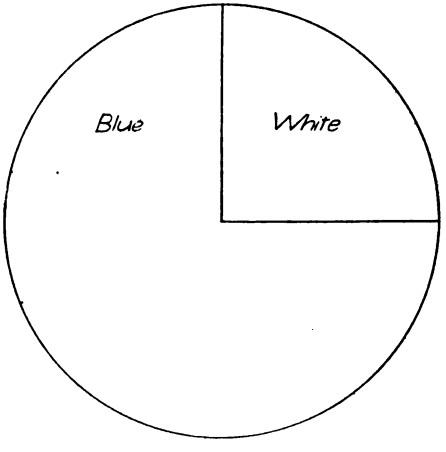


Fig. 15. Discs arranged for producing tints.

70. Tints

Take a blue disc and a white disc of the same size, arrange them so you have the following combinations: Bu. 75% and W. 25%.

Rotate the discs and record the results in form of equations. Thus:

Bu75% + W25% =

(Name the color from the standard colors, a color chart, silk samples or from your knowledge of color names). Shift the discs so as to get

Bu. 50% + W50%; Bu. 25% + W75%.

Use also yellow, red and green with the white mixtures and record the results.

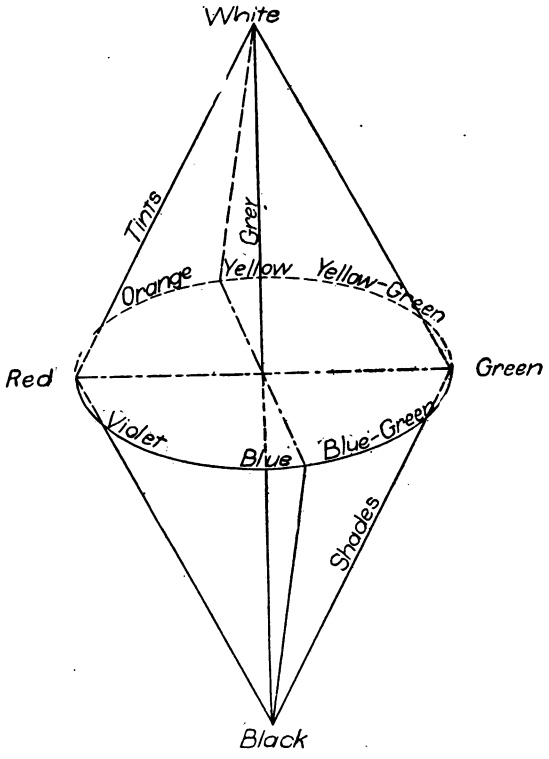


Fig. 16. Diagram showing the relations of various colors, shades and tints. Saturated colors are located on the plane of the two cones. Opposite each color is its complementary, i. e., if the color opposite were mixed with it a grey would be produced. The adding of white produces tints until white is reached at the apex of the top cone. In the same way shades are shown on the lower cone of the diagram. A line running from one point to the other should represent all shades of grey from white to black.

Materials—Colored discs, white discs, measuring disc, samples of standard colors and tints, rotator.

71. Shades

Take a blue disc and combine it with a black disc of the same size so that you have the following combination:

Bu. 75% + Ba. 25%.

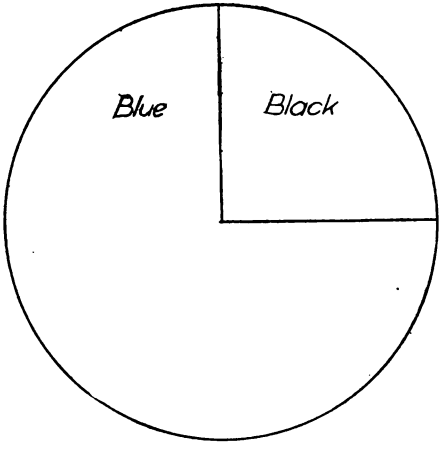


Fig. 17. Discs arranged to produce shades.

Rotate the discs and name the resulting color. Shift the discs so as to get

Bu. 50% + Ba. 50%; Bu. 25% + Ba. 75%.

Repeat the experiment, using yellow, red and green with the black mixtures and record the results.

Materials—Colored discs, black discs, measuring disc, standard colors and shades, rotator.

72. Mixing Various Colors not Complementary

Mix red and blue in the following proportions and name the resulting colors:

R25% + Bu. 75% = ?
R50% + Bu. 50% = ?
R75% + Bu. 25% = ?

In the same way combine blue and green; green and yellow; yellow and red.

Materials—Colored discs, measuring disc, standard colors, rotator.

73. Mixing Blue and Yellow to Produce Neutral Grey

Mount two large discs of blue and yellow on the color mixer, on them mount smaller black and white discs. Change the relative amounts of blue and yellow and the black and white until the colors produced by both sets of discs is the same or matches. Measure each disc and state the result in the form of an equation. Thus:

Bu.----% + Y----% = Ba.----% + W----%.

Note: Because the colors may not be pure a third may have to be added to the color group.

Materials—Colored discs, small black discs, small white discs, rotator, measuring disc.

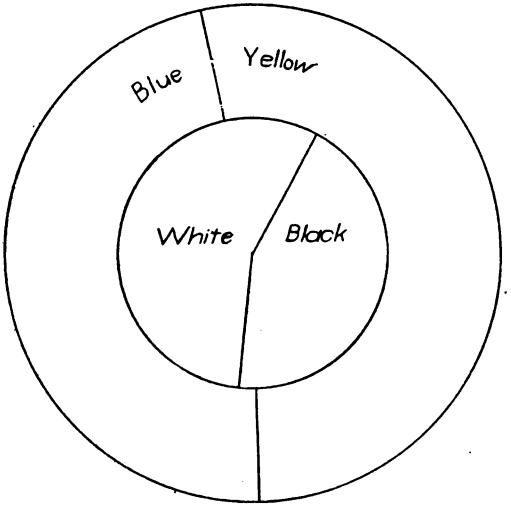


Fig. 18. Discs arranged to produce a grey.

74. Mixing Red and Green to Produce Neutral Grey

In the same manner as indicated in the previous experiment get a red and green mixture to match a mixture of black and white. A third color may have to be added because of impurity of the green or red. Fig. 19 shows the method for mounting the discs and adding a third color.

Materials—Colored discs, small black discs, small white discs, rotator, measuring disc.

75. Mixing More Than Two Colors to Produce a Neutral Grey

Take 50% of each of the colors used in the

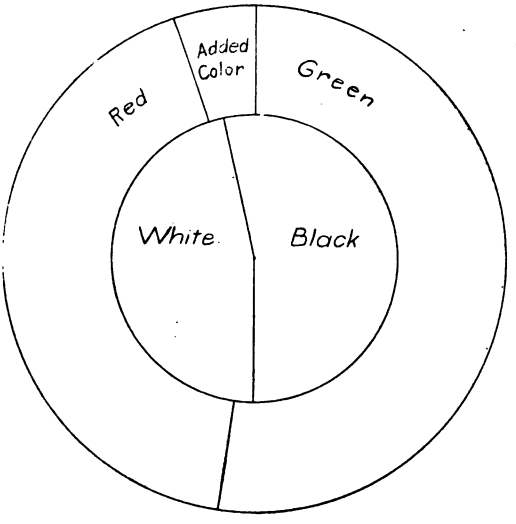


Fig. 19. Discs arranged to produce a neutral grey. Method of introducing third color is shown.

experiments, Nos. 73 and 74, and place them on the color mixer. Then divide the black and white ratios in each of the above mixtures by two, adding the quotients and mount the small black and white discs on the colored discs in the ratio indicated by these sums. Rotate and note if the mixtures match. How can this be said to be a check on the former mixture? If they do not match, what reasons can you give for the result?

Materials—Colored discs, small black discs, small white discs, rotator, measuring disc.

76. Color Contrast

Place a strip of grey paper 10 cm. long and 1 cm. wide on a sheet of red paper. Look at the small strip a few moments and note the color that may seem to appear on it. Cover the whole sheet with a sheet of very thin tissue paper. Does this increase the amount of color that appears on the grey strip? Why? By means of a color mixer upon which are mounted a black, white and colored disc, match the appearance of the grey strip. Get five or more grades of grey from a very light grey to a very dark grey and record the amount of simultaneous contrast color produced on each by the equations gotten from the color mixer. Try yellow, blue, green and other colors. What relation does the amount of induced color bear to the grey and the colored background?

Materials—Colored sheets of paper, small grey discs or strips of paper, tissue paper, black, white, colored discs, rotator, measuring disc.

77. Brightness and Contrast Color

Arrange a set of discs on a rotator as follows:

1. A large colored disc.
2. An intermediate size of black and white discs (cut on a radius).
3. A small disc the same color as no. 1. (See Fig. 20).

When these discs are rotated it will give a grey band upon which a contrast color will ap-

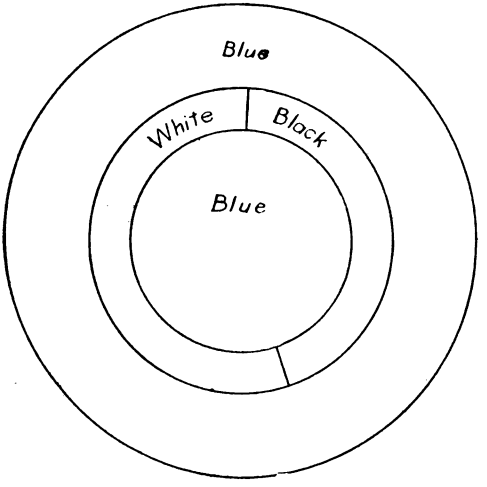


Fig. 20. Showing arrangement of discs for contrast color.

pear. Change the relative amounts of black and white until the most color is induced on the grey. Record the amount of black and white. What can you say of the relation of the amount of black and white to the brightness of the colors? Can the brightness of colors be measured in terms of the amount of black and white upon which the most contrast color appears?

Materials—Large colored discs, small colored discs, intermediate black and white discs, rotator, measuring disc.

78. Brightness Contrast

Place some pieces of grey paper, 10 cm. long and 1 cm. wide on colorless backgrounds of different brightness. Note the brightness con-

trast, describing its nature. Does the contrast increase or diminish as you look at it? Is there a change in the size of the pupil? How can the pupillary effect be eliminated?

Materials—Grey paper, various white papers.

79. Contrast Color in Shadow

Provide two sources of illumination for a dull white surface. This can be done by means of openings through a screen before a window or apertures in a dark room. Between these sources of light on a white surface place a cane, rod or ruler vertically so that two shadows are cast on the white surface, one from one opening in the screen and the other from the other. Place a colored glass before the one opening and enough clear glass before the other to make the colorless illumination of about the same intensity as that of the colored light. Note the contrast color as it appears in the colorless shadow. Change the colors by means of other glasses. Change the relative intensities of the two sources of light. Carefully note the results in each case.

Materials—White sheet of paper, ruler or pencil, colored and plain glass.

80. Negative After Image

Look steadily for a few moments at a small white disc on a black or dark grey background. Then look steadily at a dot placed on a neutral

grey background. What image forms around the dot? Take a stick, that has a glowing coal on the end, into a dark room and wave it slowly in a large circle. Immediately following the stick will be the positive after-image followed by a dimmer negative image. Note its color in comparison with the positive image. Try to get after-images of various objects on various backgrounds. Also try to get the after-image with the eyes closed.

Materials—Small white disc, black or grey background, glowing fagot.

81. Effect of Time of Fixation on the After Image

Make a black background about 40 cm. square. On the center of this background place a white square 10 by 10 cm. In the center of this white square should be a black disc or dot about 1 cm. in diameter. This is the background from which the stimulus is received. For a background upon which the image is to be projected arrange a card board or sheet of paper with a neutral grey color (40 cm. square) on the center of which has been placed a black disc 1 cm. square. Look at the stimulus 5 seconds, then look at the projection background, telling your

partner when the negative after-image appears and disappears. By observing a watch the experimenter can record the time of appearance and the time of its non-appearance until the after-image ceases to appear. A good way to record these times is to put down the number of seconds that have elapsed as the subject calls out the disappearance and appearance of the after-image, making a — sign over the numbers denoting the absence of the after-image.

Look at the stimulus 10, 15 and 20 seconds and record the results as above.

Materials—Card board backgrounds, colored squares, small discs or dots arranged as above.

82. Effect of the Stimulus Field on the After Image

Use the same apparatus as directed and described in experiment No. 81. Instead of the white square upon the black background, use it upon various colored backgrounds; also use various colors of the small squares. Note the duration, color and nature of the after-image.

Materials—Same as in Experiment No. 81, and colored squares.

83. The Effect of the Background Field on the After Image

Use the same apparatus as in previous experiments. Instead of the neutral grey back-

ground upon which to project the after-image use other shades of grey and also colored backgrounds. Record the duration and color of the after-image.

Materials—Same as in Experiment No. 81, grey and colored backgrounds.

The last three experiments can well be combined into one experiment. In the form of a table the records should show, the length of time of the stimulus, the stimulus color, the color of the background around the stimulus, the color of the background upon which the after-image is projected, the duration of the after-image, the color of the after-image, and any peculiarities that occur.

CHAPTER 10.

Movement

84. Tapping Test

Direct the subject to tap, by means of a metal rod, on a metal plate as rapidly as possible for 15 seconds. Record the number of taps by means of an electric counter which is connected in series with batteries, the brass plate and the rod.

Materials—Metal plate, metal rod, electric counter, batteries, wires and connections.

85. Detection of Passive Movements

Bare the arm to above the elbow and lay it on a hinged board (Fig. 21) which is moved by means of a windlass at the top. How many

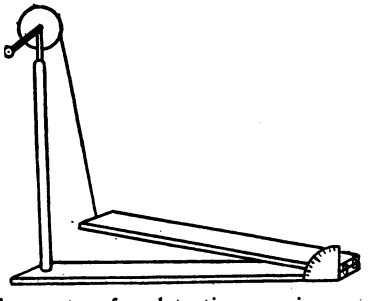


Fig. 21. Apparatus for detecting passive movements.

degrees up and how many degrees down can the board be moved before the movement is

detected? Where do you begin to feel the movement? Do you detect a sensation of tension preceding that movement? Analyze the source of the sensations as closely as you can. Take a record of the number of degrees in each direction 5 times, 10 in all.

Materials—Hinged board, protractor.

86. Right and Left Handedness

The strength of the right hand as compared with the left hand can be measured by means of a dynamometer. Grip as hard as you can

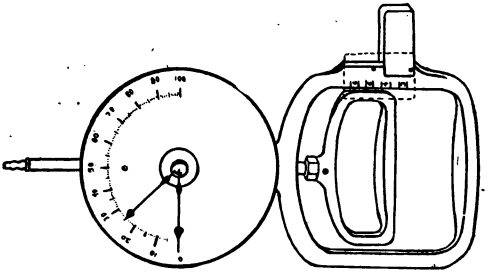


Fig. 22. Hand Dynamometer.

with the right hand, wait just one minute, grip again, wait a minute again and then grip. Average the three readings for the grip of that hand. Repeat the experiment for the left hand. Compare the two. Compare the results of a right handed person with one who is left handed.

Materials—Hand Dynamometer.

87. Sense of Movement

Move the finger slowly and carefully; note all the sensations that go into the consciousness of the movement. Apply a strong yet not painful interrupted electric current to the joint and repeat the experiment.

Materials—Interrupted electric current.

88. Feeling of Resistance

Fit a band over a finger of the subject's hand to which a thread with a weight is attached. Blindfold the subject and have him hold his arm out horizontally away from the body and slowly lower the weight. When the lowering has begun the experimenter should noiselessly lift the weight. What sensations does the subject get? Carefully record your experiences and offer an explanation.

Materials—Weight suspended with a thread.

89. Steadiness Test

Drill a series of holes, 32, 20, 16, 13 and 11, sixty-fourths of an inch in diameter in a brass plate. Cover one end of a metallic rod one-eighth of an inch in diameter with a hard rubber handle. To the rod attach a flexible electric conducting cord which is connected with dry batteries, an electric counter and the brass plate in series. Instruct the subject to hold the rod in the holes without touching the brass

plate, for a period of 15 seconds after a preparatory signal has been given 3 seconds previous. The subject's hand and arm should be free from support. Every time the brass plate is touched a record is made by the counter. The click of the counter warns the subject that he must immediately remove his rod from the brass plate. The size of the hole and the number of contacts in 15 seconds form the basis of the record. Use right and left hands.

Materials—Brass plate with proper sized holes, metallic rod, flexible lamp cord, batteries, electric counter, connections.

90. Steadiness and Accuracy

Mount two straight copper or brass strips about 40 cm. long so they converge until they will just bind a metallic stylus at the end. (Fig. 23). The open end should have the strip 5 times the diameter of the stylus apart. The

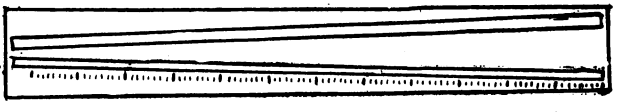


Fig. 23. Apparatus for testing steadiness and accuracy.

metallic stylus, a dry battery, a sounder and the two metal strips should be connected in series so that when the stylus touches one of the strips it will make a circuit.

Try to draw the stylus as far between the

metal strip without touching as possible. As soon as the sounder indicates that a side has been touched record the distance from the open end. Repeat the experiment 10 times. Try different positions right and left hand, rested and fatigued conditions, etc.

Materials—Brass strips, properly mounted, metallic stylus, batteries, sounder, millimeter scale.

91. Judgment of Weight

Bare the arm and support it in a comfortable resting position. Close the eyes and have the experimenter lay a weight on the forearm, after having placed a piece of felt on the arm. Report various experiences that give information leading to a judgment of the weight. After a brief rest repeat the experiment with a rather heavy and rather light weight.

Materials—Felt, weights.

92. Judgment of Weight with an Anaesthetic Skin

Spray the skin with ether and repeat the judgment of weight experiments. Carefully compare your experiences with those of the previous test.

Materials—Felt, weights, ether, atomizer.

93. Size Weight Illustration

Take a very small box or bottle (made opaque by covering it with paper) and fill it with shot or sand. Take a large box or bottle (opaque) of the same general shape and fill it until it appears to be the same weight as the small one. Weigh each box and record the difference in weight. This difference in weight is the amount of illusion produced by the difference in size. Repeat the experiment 10 times, averaging the results. It is best for the subject not to know the result until the end of the experiment.

Materials—Boxes, sand.

94. Fatigue, Intermittent Contraction

By means of an ergograph exercise a muscle

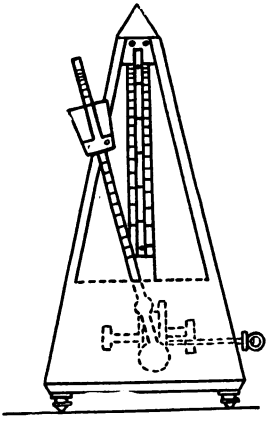


Fig. 24. Metronome.

or set of muscles by pulling against a resistance, keeping time with a metronome. Be sure to pull as hard as possible each time. Get a record of these pulls on a piece of smoked paper if possible. Study the records, noting the warming up period and the "second breath" effect. Change the interval between pulls and note the effect.

Materials—Ergograph, metronome.

95. Fatigue, Constant Contraction

Pull against the resistance as hard as you can and hold this contracted position of the muscles as long as possible, recording the relaxation by means of a curve.

Materials—Ergograph.

96. Rest

Fatigue a muscle by intermittent contractions, rest 5 seconds and then begin again. Can you pull as much or can you continue as long? In the same way investigate the effect of 10, 20, 30, 40, 50, 60, seconds, 2, 5, 10, 15, 20, and 60 minutes rest intervals. Discuss fatigue and rest in the light of your data.

Materials—Ergograph, metronome.

97. Practice

Prepare a target at which large marbles are to be thrown. Behind it a sheet of carbon paper

is to be placed and a copy of the front target. Throw at the center of the target 10 times; remove the copy behind the carbon paper, inserting a new one and throw 10 times again. Repeat the experiment until sufficient data is obtained. Measure the amount of error on each successive target and plot a curve showing the amount of improvement with each series of 10 trials. Other practice and learning experiments can easily be devised such as, the speed of typewriting, running a given distance, taking short hand notes, etc.

Materials—Marbles, target, carbon paper.

98. Learning New Motor Coordinations

Place a paper, upon which is the colored outline of a six pointed star, on the table a little out of the true vertical and horizontal positions. Place a mirror on the table a little beyond the paper that is inclined about 5 degrees from the vertical. Place a screen before the subject over the drawing so the drawing can be seen nowhere but in the mirror. Have the subject take hold of the pencil and assist him in putting it to the starting point. Ask him to trace the outline as rapidly as possible, never stopping the pencil. Start a watch and record the time required to get around the star. The quality of the drawing is to be considered as well as the time required.

Repeat the experiment say 50 times and

draw a practice curve. Repeat the same experiment, but instead of following a figure already drawn, draw a rectangle with its diagonals.

Materials—Outlines of a star, mirror, clamps, screen.

CHAPTER 11.

Perception

99. Reversible Figures

Look steadily at some reversible figures, such as the staircase figure, the outline of a

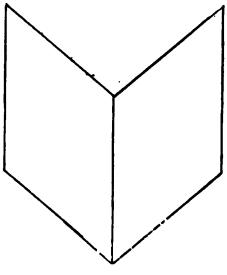


Fig. 25.

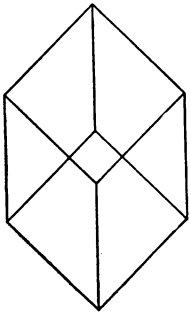


Fig. 26.

cube, the open book figure, etc. What is the effect of looking at different points of the figure first? What effect does a predetermined idea

of the position have upon the way you see the figure?

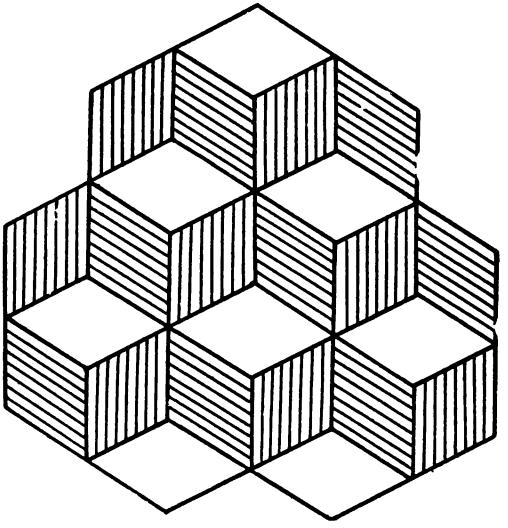


Fig. 27.

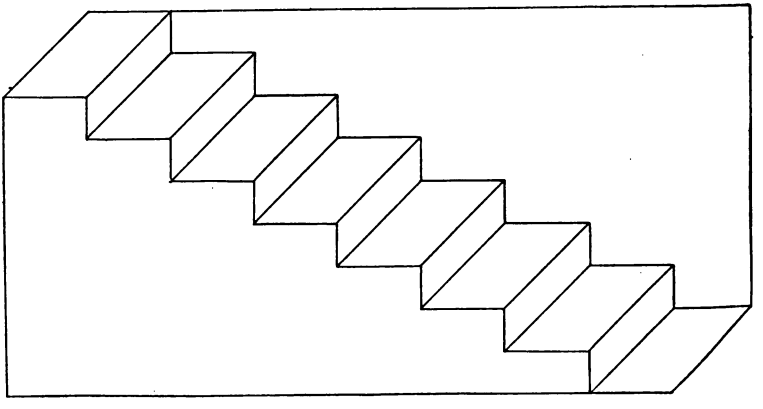


Fig. 28.

Look steadily at the figures for some time and by means of a metronome time the image in each position. Do the reversals occur more often as time goes on? Give as full as explanation as possible.

100. Measuring Amount of Illusion

Mount three Dart head shaped cards on a slide about 1 meter in length.

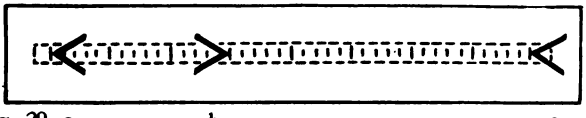


Fig. 29. a b c

The center figure (b) should be mounted on a movable slide which can be actuated by means of cords by the subject seated about 10 feet away.

Move (b) back and forth until its central point seems equidistant from (a) and (c).

Measure and record 10 such attempts at this central placing 5 times toward (a) and 5 times from (a) toward (c).

What effect does practice have on the amount of illusion? What is the cause of the illusion?

Materials—Sliding figures, meter stick.

101. Puzzle Pictures

Examine a puzzle picture. Record your

introspections as you are finding the hidden forms. Note the time it takes to find the picture the first time.

After 5 or 10 minutes take up the same picture. How long does it take to find the hidden figure this time? What can you say of the clearness with which you saw the hidden figure the second time as compared with the initial image that you got the first time?

Materials—Puzzle pictures, watch.

102. Stereoscope

Take the frustum of a cone, (a large cork)

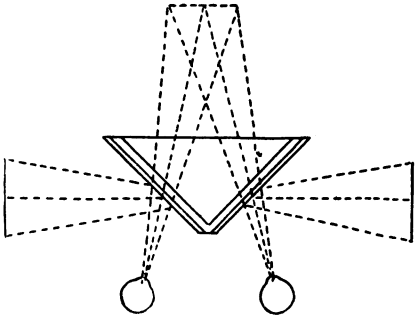


Fig. 30. Plan of the Wheatstone Stereoscope.

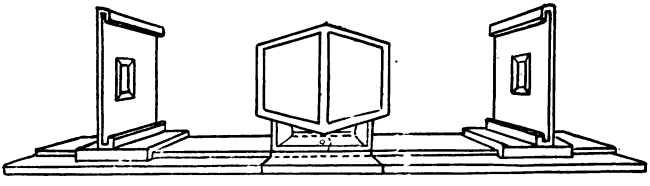


Fig. 31. Wheatstone Stereoscope.

and mount it small end toward you on a level with the eyes. Hold your head in one position and look at it first with one eye then with the other. Represent the planes of the base and top by means of circles in their respective relative position as they seem for each eye. Draw the pictures for each eye on a slip of paper the size of a stereoscope slide. Locate the center of the drawings about 3 inches apart. Place this slide you have made in a stereoscope. Do you get the sense of perspective?

In the same way make a drawing of a sphere with a meridian upon it.

Make a slide that will show the small end of the frustum of a cone pointed away from you.

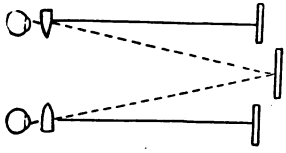


Fig. 32. Plan of the Brewster Stereoscope.

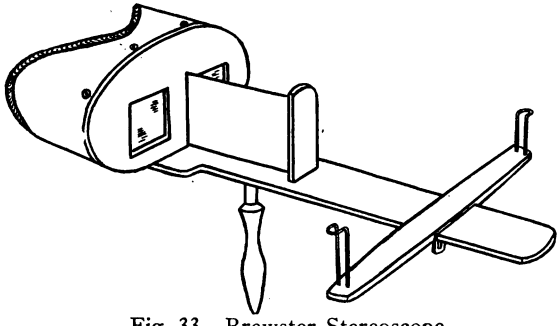


Fig. 33. Brewster Stereoscope.

Explain the workings of a Brewster stereoscope.

Materials—Drawing instruments, frustum of a cone, globe or sphere, stereoscope.

103. Sterescope

Take a series of slides representing fusion, partial fusion, geometric forms in perspective, retinal rivalry, binocular color-mixing, stereoscopic lustre, etc. Number and classify the

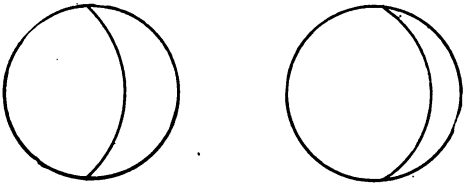


Fig. 34.

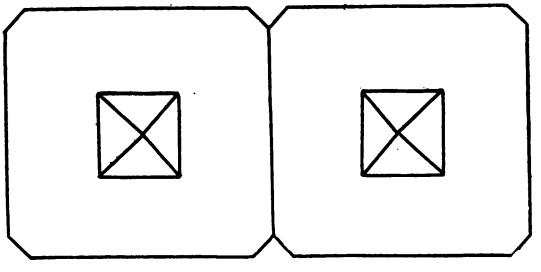


Fig. 35.

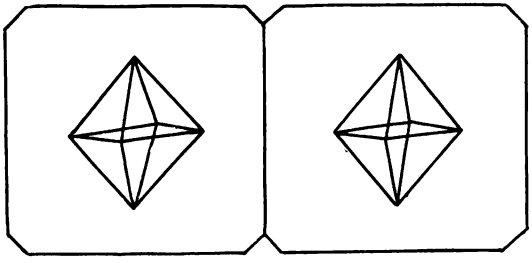


Fig. 36.

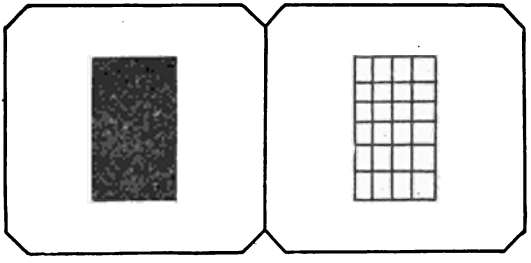


Fig. 37.

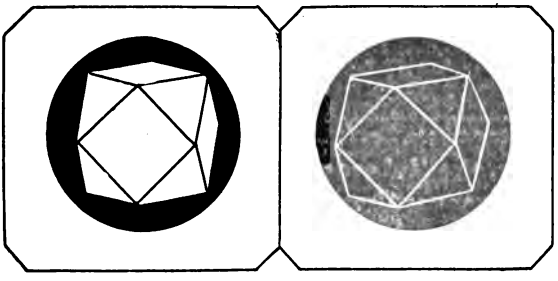


Fig. 38.

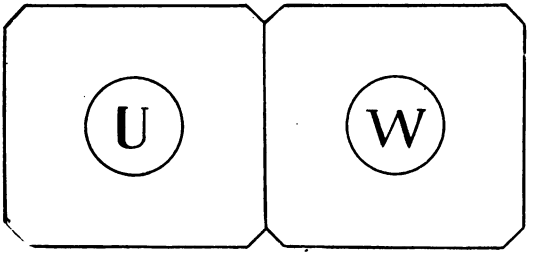


Fig. 39.

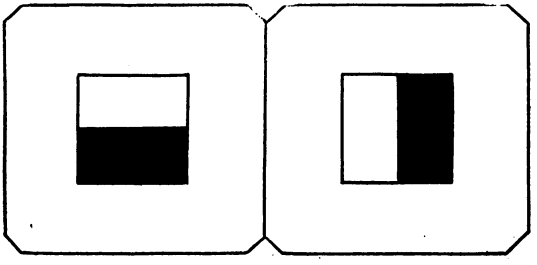


Fig. 40

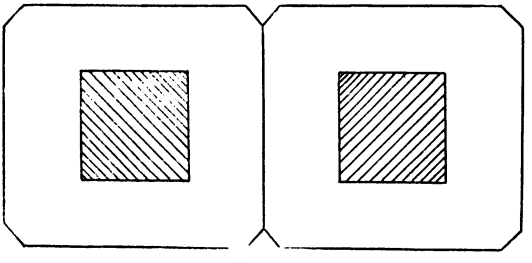


Fig. 41.

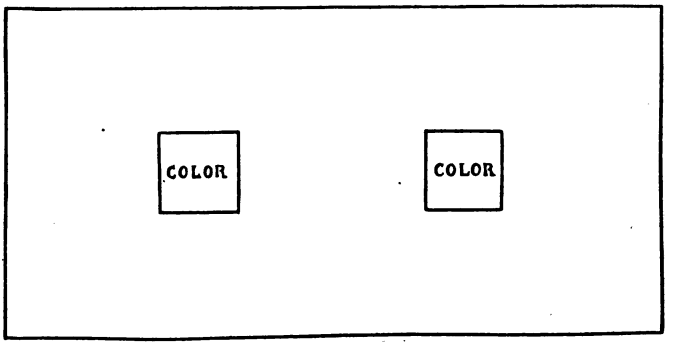


Fig. 42.
Note: All the examples of stereoscopic views are ½ size.

cards stating what they show and explain the results. Make drawings showing the principles upon which the Wheatstone, Brewster and other forms of the stereoscope operate.

Materials—Special stereoscopic slides.

104. Other Forms of Stereoscopic Vision

Take a pair of glasses, one red and one green lens and pictures that have printed stereoptically for this effect in red and green. Do you get perspective? In terms of binocular vision and the principles of the stereoscope explain how the effect is gotten. What happens if you reverse the glasses?

Materials—Special pictures, eye glasses with one red and one green lens.

105. General Stereoscopic Slides

Look at a set of stereoscopic slides as if you

were looking through small windows upon a distant view and then answer the following questions:

1. In gaining an idea of a new place, compare the value of the stereoscope with the projected picture, a black-white picture and a colored picture.

2. Do you get a clear sense of perspective?

3. Do you see the picture as natural size, far away or miniature near by?

4. Do you get the best effects right after looking or after looking some time?

5. Do you get a vivid sense of being actually at the place?

6. In what subject matter would stereoscopic slides be of value?

Materials—Stereoscopic slides, stereoscope.

106. The Exposure Apparatus

The "exposure appartus" is a screen, behind which is placed the object to be exposed. The screen falls and affords a view through a hole in itself at the objects behind. The exposure should be so short in time that it is impossible for the eyes to make two fixation pauses—i. e. to look at two separate points of the object. About one-fifth of a second is the longest time that can be allowed in these experiments.

In using this apparatus you may see how much is perceived in a single exposure (method of accuracy), or you may count the number of repeated exposures needed to get a correct perception (method of time); or you may very well combine the two methods in which case you will have a series of answers from the subject, probably increasing gradually in accuracy till perfection is reached. The series of imperfect perceptions give some idea of the process by which percepts grow from the vague to the definite.

Draw a diagram of the instrument and explain its use.

Materials—Exposure apparatus.

107. Perception of Irregular Forms

Find the greatest number of dots, irregularly placed, that can be counted by one exposure; and the effect of repeated exposures on the accuracy of estimation of larger numbers than can be correctly perceived in a single exposure. Provide slips of paper, of suitable size to fit the instrument, all of the same size and shape, and with the matter to be exposed always at the same part of the slip: the slips are also to be inserted in the same position, so that the observer will, after a little practice, know exactly where to look. Prepare slips with dots in irregular groups, from 3 to 12 in number, and expose them to the subject, who is not to

know beforehand how many dots are on the slip. If he perceives the number correctly, record the fact; if incorrectly, give him further trial till he is sure of the right number. Take care not to give him any external aid. Record all his answers, so as to state, at the end of the experiment, within what limits his errors lie at each stage. Try to make out the course of progress from less accurate to more accurate perceptions of the number.

Materials—Exposure apparatus, prepared slips of paper.

108. Perception of Regular Forms

By means of coordinate paper, prepare dot figures of varying degrees of regularity, but all containing about the same number of dots. Determine the number of exposures for each figure.

Materials—Exposure apparatus, slips of paper, prepared with regular figures.

109. Perception and Reproduction

Use material similar to that in the last experiment, but require the subject, not simply to count the dots, but to reproduce the figure, locating the dots on coordinate paper.

After each exposure, the subject attempts to duplicate the figure which was shown him. Preserve his attempts in their order and exam-

ine the development of an accurate percept with the repetition of the exposure.

Materials—Exposure apparatus, prepared slips of paper.

110. Perception of Lines

Repeat the preceding experiment with this difference, that the figures are made of lines. Prepare a series of such figures, running from very simple to fairly complex. Most of these figures should be meaningless, but one or two geometrical forms or drawings of objects may be introduced, and the effect noted.

Materials—Exposure apparatus, slips of paper with line drawings.

111. Perception of Various Forms of Material

Correlate the results of these three experiments; that is, compare the results for all the individuals of the class, to see how those who have a wide field of clear vision read fast and take large bites of the reading matter.

112. Speed of Reading

Select a passage of reading matter and by means of a stop-watch, determine the speed of reading for a story and a scientific passage. Reduce your figures to fractions of a second per word.

Materials—Reading matter, stop-watch.

113. Visual Span in Reading

Compare the extent of the horizontal field of clear vision, as determined in experiment 108 with the amount of reading matter covered in one eye fixation in reading. The average amount can be estimated from the number of pauses per line. The pauses in the eye movements can easily be seen and counted. Sometimes it does not disturb the reader so much if the experimenter counts the eye movements in a mirror so adjusted as to plainly show the reader's eyes. Does the amount read in one reading pause equal the amount included in the field of clear vision?

Materials—Reading matter, mirror.

114. Correlation of Visual Span in Various Forms of Material

Correlate the results of these three experiments; that is, compare the results for all the individuals of the class, to see how far those who have a wide field of clear vision read fast and take large bites of the reading matter.

115. Visual Span for Different Kinds of Printed Matter

The amount of various sorts of printed matter that can be grasped at a single exposure can be measured on the exposure apparatus. Use miscellaneous letters, nonsense syllables, disconnected words, phrases, and finally,

phrases in context. For the last make the subject familiar with the context before the exposure. Put more matter on the screen than can be perceived. Repeat the experiments, averaging the results for each sort of printed matter used.

Materials—Prepared reading matter, exposure apparatus.

116. Perception of Letters

Prepare a sheet upon which all the letters of the alphabet are so arranged that each letter appears 10 times in four lines. Repeat this until every letter appears 50 times. Arrange the letters in a chance order, taking care that no one letter appears twice in consecutive order.

Give the subject a letter which he is to cancel every time it appears. Record the time it takes to cancel the given letter. If any are

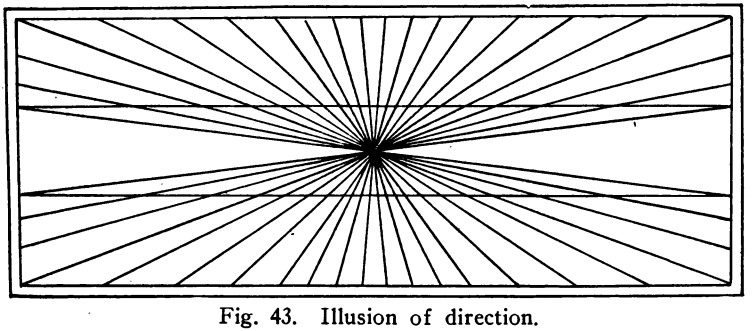


Fig. 43. Illusion of direction.

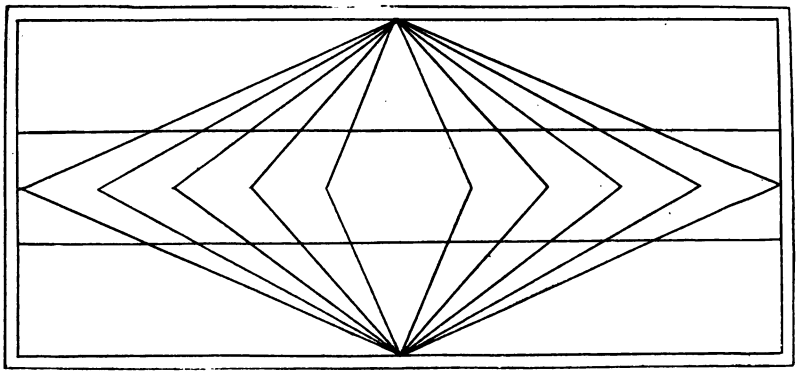


Fig. 44. Illusion of direction.

missed calculate the time per letter required for those cançelled and add it for each letter missed. This then becomes the final recorded time. A record can also be kept of the time per letter. Does the letter used make a difference in time?

Materials—Prepared list of letters, stop-watch.

117. Illusions of Direction

Study the figures giving as full an explanation as possible. Draw other figures that produce illusions.

118. Illusions of Extent

What factors enter into the cause of an illusion of extent? Study the figures and explain the illusion and its causes.

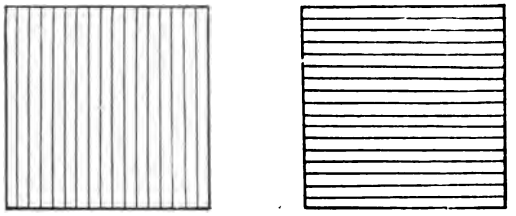


Fig. 45. Illusions of extent.

CHAPTER 12.

Attention

119. Masson Disc Experiment

Take a disc of white card-board from 20 to 25 cm. in diameter. Along one radius paste a series of small black squares 5 mm. by 5 mm., 5 mm. apart. This disc is known as a Masson disc. Place the disc on a rotator and run it at a speed of approximately 2,000 revolutions or more per minute. Each black square will produce a faint ring of grey on the surface of the disc. The rings will be fainter and fainter toward the circumference of the disc.

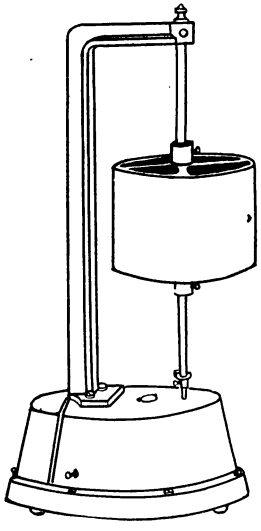


Fig. 46. Kymograph.

The observer should seat himself about two meters from the rotating disc and place his hand on a bulb connected with a recording tambour writing on the slowly revolving drum of a kymograph. The observer should press on

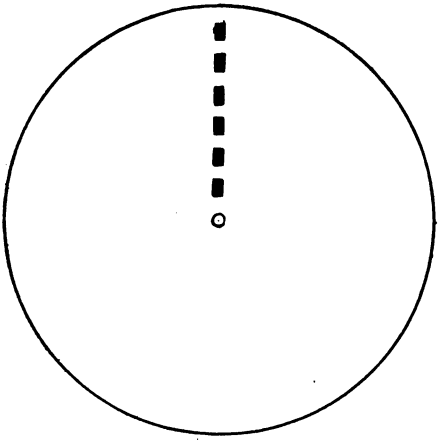


Fig. 47. Masson Disc.

the bulb when the greatest number of rings are visible on the disc and release his pressure as the number of visible rings decrease. A time line in seconds or fifths of a second should also be recorded simultaneously with the tambour line. This apparatus will measure the fluctuations of attention, to a visual stimulus.

Note the effect of distracting noises. Do you get a regular rhythmic fluctuation? What variations occur? It is also interesting to record a breathing and pulse tracing and work

out the relation of the fluctuations of attention to changes in breathing and heart beat.

Materials—Rotator, Masson disc, kymograph, recording tambour, time-marker, bulb.

120. Attention in Hearing

Substitute for the Masson disc in the former experiment a watch so far away that its ticking can scarcely be heard. Does its ticking fluctuate in the same way? This experiment must be carried on in a very quiet room, or better still, a sound proof room.

Materials—Watch, kymograph, tambour, time marker, bulb.

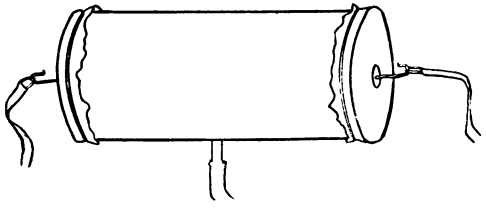


Fig. 48. Pneumograph for recording breathing.

CHAPTER 13.

Perception of Time

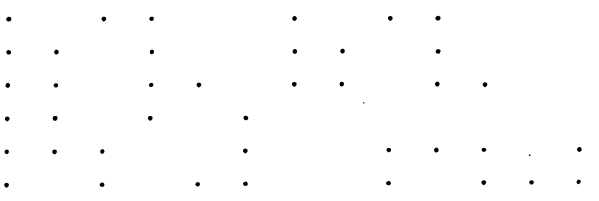
121. Rhythm and Time Sense

Connect a telegraph key in such a way with an electric recorder so that taps on the key can be recorded on the drum of a kymograph. A time line in fifths of a second should also be traced. Start a metronome and let the observer tap on the key synchronously with it. Let the metronome run for, say, 20 beats, then stop the metronome. The observer is to continue his tapping at as near the same rate as possible. What intervals are reproduced most accurately? Do the reproductions tend to slow up or increase in speed?

Materials—Telegraph key, electric recorder, kymograph, metronome.

122. Rhythm and Time

Arrange an apparatus giving beats of the same intensity so the time interval between them differs. Let the space between the dots represent time, then some of the following combinations can be arranged:



Other combinations can be tried and their effect studied.

A regular beating metronome can be placed in a box, the lid of which can be opened and closed to produce the intervals.

Materials—Metronome, box with hinged lid.

123. Subjective Rhythm

Take a metronome, whose beats are equal in quality and intensity, and set it at various rates. Record the feeling that the various rates give you, such as tiresome, pleasant, exciting, etc. The experimenter should note any accompanying swaying or other movements on the part of the observer.

Materials—Metronome.

124. Objective Rhythm

Inclose the metronome in a box with a lid that can be opened and closed silently thus accenting various beats. In this way produce the common measures such as

Trochaic
Iambic
Dactylic
Anaspestic
Cretic

Study them in regard to their subjective effect. Accent 3, 4, 5, etc., beats in a series

with intervals of 2, 3, 4, 5, etc., of unaccented beats intervening. Do these series all give the rythmic effect?

Materials—Metronome, box with hinged lid.

CHAPTER 14.

Reaction Time Experiments

The term 'reaction' in psychology means a movement made in response to an external stimulus. The time of a complete reaction or 'reaction time' may be devided into five parts; (1) The latent period in the sense organ receiving the stimulus, (2) the time consumed in the conduction of the impulse from the sense organ to the appropriate sensory center of the

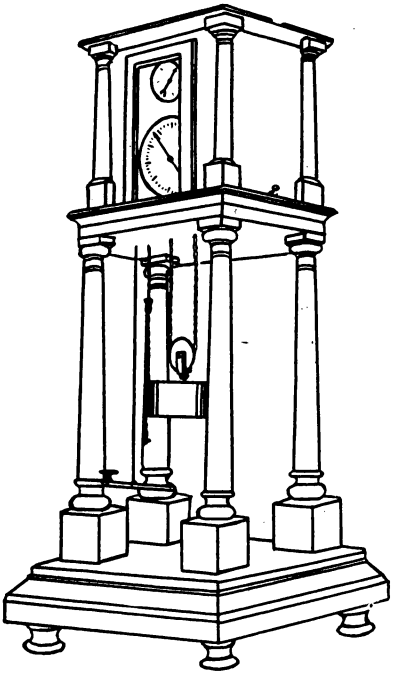


Fig. 49. Hipp Chronoscope.

brain, (3) the time consumed in cortical elaboration or the association process, (4) the time consumed in the conduction of the impulse from the motor area of the brain down to the cord and out to the striate muscle that is to make the movement, (5) the latent period of the muscle itself.

Various methods are employed for the measurement of 'reaction time.' The graphic method, or some form of a chronoscope, are usually used in the laboratory experiments. Whatever form of apparatus is available, it is important to master its construction and use. Learn to adjust it properly and accurately. Remember that the time intervals to be measured are short, therefore every precaution must be taken to assure accurate results.

All results should be averaged and the mean variation of the individual reactions from the average found.

Always take a few preliminary records to see that everything is in good working order and to see if the problem is clearly understood.

125. Natural Auditory Reaction Time

The subject should seat himself in a natural, comfortable position and lay his finger lightly on the button of the reacting key. It is best for him to close his eyes so as to avoid shifting of the attention. The experimenter having

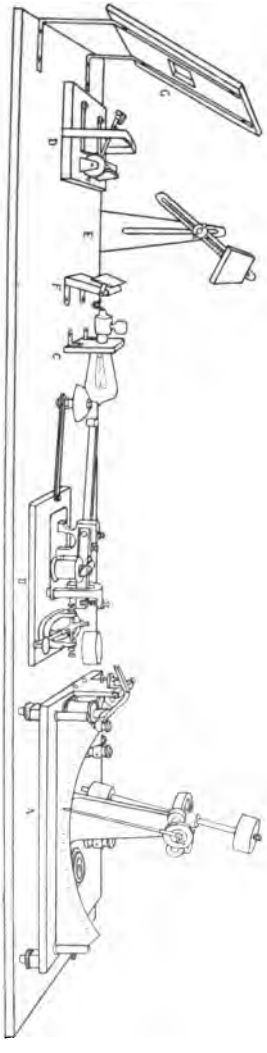


Fig. 50. Bergstrom Pendulum Chronoscope and Accessories

adjusted the apparatus says "ready" or gives some other preliminary signal. After the signal he waits from one to two seconds and then gives the sound stimulus. The subject presses the button as quickly as he can after having heard the stimulus signal. While his record is being made by the experimenter he can take notes of his introspections. The subject should not know what his records are until the close of the experiment. It is well for the two members of the experiment to take turns at being subjects for the experiment so as to avoid fatigue effects. Take 100 records for each subject. Make careful notes as to the nature of your attention the agreement of what seems to be very short and very long times with the actual recorded times, the cause of premature reactions, etc.

Materials—Chronoscope, with accessories for auditory stimuli.

126. Auditory Sensory Reaction Time

The sensory attitude is a preparation to observe the stimulus as well as to react. There is a focus of attention on the stimulus. The subject is certain the proper stimulus has been given. He then reacts as quickly as possible. It is hard to describe this form of reaction. The student can likely discover what is meant in the trial series of experiments. After feeling that you are conscious of the emphasis of at-

tention on the stimulus, voluntarily assume this attitude and record 100 reactions. Take them in sets of 10 or 25 with rest periods between the sets. Describe, as nearly as you can, your attentive attitude. Did you make any premature reactions? Use the same stimulus as in the natural auditory reactions and observe the same precautions.

Materials—Chronoscope, with accessories for auditory stimuli.

127. Auditory Motor Reaction Time

The usual motor attitude consists solely in a preparation to make the movement, not to observe it as it occurs. It is often said that the motor attitude for reacting consists in the attention being focused on the movement. This must not be interpreted in the sense of observing the movement itself, but of getting yourself into the best motor readiness for the movement. The stimulus comes on as a sort of "shock" setting off this movement for which you have prepared yourself. As compared with the normal or natural reactions the voluntary motor attitude is characterized by a greater feeling of effort. Describe your attentive attitude as fully as possible. Compare the reaction times with those of previous experiments. Take at least 100 records. What can you say of the relative size of the mean variation and the number of premature reactions?

Materials—Chronoscope, with accessories for auditory stimuli.

128. Visual Natural Reactions

Take 100 reactions to a visual stimulus assuming the natural attentive attitude. Care must be taken to make the appearance of this stimulus noiseless, because auditory reactions are usually faster than visual. The subject, if he heard any sound, would react to it rather than to the visual stimulus.

Materials—Chronoscope, with accessories for visual stimuli.

129. Visual Sensory Reactions

Record 100 reactions to a visual stimulus with the sensory attentive attitude.

Materials—Chronoscope, with accessories for visual stimuli.

130. Visual Motor Reactions

Record 100 reaction-times to a visual stimulus with the motor attentive attitude.

Materials—Chronoscope, with accessories for visual stimuli.

131. Tactual Reactions, Normal

Records can also be made of reaction times to tactual stimuli. Here also care must be taken

to avoid any auditory stimulation. The three different attentive attitudes can be repeated for this stimulus. Record 100 natural tactual reactions.

Materials—Chronoscope, with accessories for tactual stimuli.

132. Tactual Senory Reactions

React 100 times to a tactual stimulus taking on the sensory attentive attitude.

Materials—Chronoscope and accessories for tactual stimuli.

133. Tactual Motor Reactions

Record 100 reaction-times to a tactual stimulus with the motor attentive attitude.

Materials—Chronoscope with accessories for tactual stimuli.

134. Discrimination Time

Arrange a screen or revolving mirror in connection with the chronoscope so that when a sheet of paper is exposed to view, the chronoscope will be started. Install two recording keys, one for the right hand, the other for the left. Expose two colors of papers, one at a time, in irregular order. The observer must always react with one hand for one color and the other hand for the other color. Take 100 reactions in which

there has been a discrimination of two colors. Compare the time with that of the simple reactions. This experiment can be continued by introducing more keys and colors.

Materials—Chronoscope with accessories for exposing colored paper and additional reaction key.

135. Discrimination Time

Repeat the former experiment with the two shades of grey that differ very little or with tints and shades of the same color. What is the relation of the ease of discrimination to discrimination time?

Materials—Chronoscope with the same accessories as in the former experiment, greys.

136. Recognition Time

An exposure screen is arranged as in the Discrimination Experiment. On this screen expose words, letters, pictures or other material for which you wish to measure the recognition time. For the reacting key a sound key may be used which records the word when spoken. The word may be spoken by the observer and the experimenter can react with the ordinary touch key, allowing the spoken word to be the auditory stimulus for a simple auditory reaction. The total time then would be the observer's recognition time plus the experimenter's

simple auditory reaction time. The average auditory reaction time can be subtracted from the total average leaving the average recognition time. No less than 100 records should be taken.

Materials—Chronoscope with accessories for exposing words, etc.

137. Free Association Time

Arrange the apparatus in the same way as for recognition time. Present words and instead of pronouncing the word itself speak the first word that comes to your mind after the word shown on the screen. Record the stimulus word, the associated word and the association time. After having the record for 50 or 100 associations classify them into associations of meaning—

coordination, e. g.....baby-infant
super ordination.....Nile-river
sub ordination.....lake-Ontario
part-whole ..... collar-coat
whole-part .....wagon-wheel

sound associations—

letters or parts of words...fool-foolish
rhyme ..... cat-rat

associations of cause.....fire-heat
serial associations..... three-four
associations of contiguity in space..locomotive car.

The classifications given are not exhaustive but are merely suggestive. Add any that may be needed in your series.

Materials—Chronoscope with accessories for exposing words, etc., word lists.

138. Controlled Associations

With the same apparatus as in the former experiment for the free associations the time for naming the opposites, part-whole, whole-part, etc., can be measured. In any of these series the material must be prepared for the kind of control that has been agreed upon. The controlled associations times are often so long that they can be measured with sufficient accuracy by means of a stop watch.

Materials—Chronoscope or stop watch with word exposure apparatus, word lists.

139. Judgment Time

With the same apparatus as in experiment No. 136, ask the observer questions on the exposure screen which require judgment for their answers, viz: Which is the larger lake (this can be given orally) Michigan or Superior (on the exposure screen)? Record the questions and replies. Full introspective reports will be especially valuable.

Materials—Chronoscope with accessories for exposing words, etc.

140. Attention Fluctuations

Set the reaction apparatus up for auditory reactions. (Visual and tactual can also be used.) Time the interval between the "ready" signal and the stimulus for reacting by means of a stop watch. Vary the interval from 1 to 10 seconds, recording the interval and the reaction time. Take at least 10 reactions for each respective second's interval from 1 to 10 seconds. Mix the order in which the various intervals are given so the subject does not know how long he will have to wait after the "ready" signal is given until the reacting stimulus will appear. Record the reactions for each second's interval in the same column. Average the ten reactions for which there was a wait of one second, those for which there was a wait of two seconds, three seconds, etc. The "ready" signal is for the purpose of concentrating the attention of the subject. The averages then show the fluctuations that occur for various intervals. What interval, in your case, was the most favorable for quick reactions? Are there regular rhythmic fluctuations of the attention? How do your fluctuations correspond with those of others?

Materials—Chronoscope with its various accessories, stop watch.

141. Intensity of Stimulus and Reaction Time, Auditory

Vary the intensity of the auditory stimulus and record 100 reactions for each respective intensity. What effect does intensity of stimulus have on the reaction time? Do the same proportional differences exist for extreme stimulations? Do the differences occur for all kinds of reaction movements?

Materials—Chronoscope and accessories.

142. Intensity of Stimulus and Reaction Time, Visual

Perform this experiment in the same manner as the former one, except that a visual stimulus is used instead of an auditory stimulus.

Materials—Chronoscope and accessories.

143. Intensity of Stimulus and Reaction Time, Tactual

Perform this experiment in the same manner as the two former ones, using a tactual stimulus instead of the auditory and visual stimuli.

Materials—Chronoscope and accessories.

CHAPTER 15.

Judgment

144. Weber's Law for Lifted Weights

Make a series of weights so their external appearance is just the same. Have the standard 100 grams, then have a series running 101, 102, 103, 104, 105, 106, 107, 108, 109, 110 grams. Begin with the weights weighing 100 and 101 grams. Present the standard then the 101 grams weight or the heavier and the standard in promiscuous order. Have the subject report each time as to the relative weight (lighter or heavier) of the first weight presented. Repeat this until 100 judgments have been made for the first pair of weights. Repeat the experiment with 100 and 102 grams, 100 and 103 grams, etc., until no errors are made.

Repeat the whole experiment using 500, 505, 510, 515, etc., gram weights.

Repeat the experiment with 1,000, 1,020, 1,030, 1,040, etc., gram weights.

Given that any weight must be increased by 1-n of itself to be felt as distinctly heavier, from your data calculate the value of n. Will this hold true for very heavy or very light weights?

Materials—Weights.

145. Weber's Law for the Felt Length of Lines

Use the edge of a card 5 cm. as a standard by pressing it on the skin. Use cards slightly wider and wider until no errors are made in judging one wider than the standard. Repeat the experiment using a standard line of 10 cm. In the same manner as described for the Weber law in lifted weights calculate the constant for the tactual judgment of the length of a line.

Materials—Cards.

146. Judgment of Distance

Present a standard line 10 cm. long and ask the subject to draw a line just as long as the standard, on a sheet of paper lying beside it. Cover the line already drawn and repeat the drawing until 100 judgments have been made.

Repeat the experiment with standard lines 20 and 30 cm. long. Measure the reproductions carefully and calculate the per cent of error for each standard. Is the error a constant fractional part of the standard line?

Be careful to avoid any artificial means of measuring the line either conscious of unconscious.

Materials—Standard lines.

CHAPTER 16.

Imagination and Intelligence

147. Mental Imagery

Galton studied mental imagery by means of questionairre the essentials of which are reproduced here.

Think of your breakfast table as you sat down to it this morning; call up the appearance of the table, the dishes, the food, the persons present, etc.

Then write answers to the following questions:

1. Are the outlines of the objects distinct and sharp?
2. Are the colors bright and natural?
3. Where does the image seem to be situated?

   In the head? Before the eyes? At a distance?
4. How does the size of the image compare with the actual size of the scene?

1. Can you call to mind better the face or voice of a friend?
2. When **violin** is suggested, do you first think of the appearance of the instrument or the sound when it is played?

3. (a) Can you call to mind natural scenery so that it gives you pleasure? (b) Music? (c) The taste of fruit?

4. Have you ever mistaken an hallucination for a perception, e. g. apparently heard a voice or seen figure when none was present?

Describe the experience. From your above answers discuss your imagery as fully as possible.

148. Illusory Warmth

Make a box with a small flue on top and a hole in the side for the insertion of the subject's finger. Have a door arranged away from the subject through which an alcohol lamp can be placed in the box. Announce to the subject that you want to test his sensitivity to warmth and have him place his finger in the hole. Tell him to report when he begins to feel the warmth, assuring him that arrangements are such that it will not burn him. Just as the alcohol lamp is placed in the box extinguish the flame noiselessly, by placing the cap on. Note the time that elapses until warmth is reported. Study several individuals for comparative data.

Materials—Special box, alcohol lamp.

149. Completion or Filling in Tests

The Completion Tests are said to be ex-

cellent tests for retention, readiness of recall, quick and accurate association, creative imagination, in short, splendid tests for intelligence. Various materials may be used such as words in which letters have been omitted, words with syllables omitted, sentences with words omitted or paragraphs with phrases omitted. Prepare material for the test leaving blanks for the matter to be filled in. See that the subject clearly understands what is to be done. Keep the time accurately with a stop watch. Either record the time required to complete the task or limit the time and note the amount of work accomplished. Compare your results with those of other subjects. Note the attitude of the subject. Does he hesitate? Is he attentive? Does he get the meaning of the material presented?

Materials—Special blanks, stop watch.

150. Imagination and Invention

Prepare a series of ink blots that from their grotesque form will likely suggest pictures.

Tell the subject the nature of the material and that they are not real pictures but for him to leisurely examine them and tell you what objects they suggest to him. Take the blots up one at a time and allow say three minutes examination of each.

Treat the data by comparing the total number of associations with that of others.

Materials—Ink blots.

151. Vocabulary Test

Select a series of 100 words covering the range of the field of information with which the subject should be familiar. Ask him to consider each one carefully and place after it a mark to indicate,—

1. If he could define it exactly.
2. If he could define it well enough so as to give an idea of its meaning without its necessarily satisfying an expert.
3. If he is only roughly familiar with the word, has an indefinite idea of meaning.
4. If the word is new and unknown.

The following is a list suggested by Whipple:—

ageratum
amphioxus
amphora
annealed
Anthony Wayne
apocalypse
architrave
audjourdhui
Babcock test
base-hit
Bernard Shaw
Bokhara
Braille
call-loan
calorie
cantilever
Caedmon
catalepsy
Cephalic index
ceramics
chamfer
Chartism
chlorine
chromosome

clearing-house
cleistogamous
cosmogony
cotangent
dibble
dietetics
dryad
electrolysis
Elohim
entree
Eocene
Euclid
f-64
f. o. b.
gambit
gasket
glycogen
gneiss
golden section
guimpe
hedonism
hemiptera
homiletics
hydraulic press
impetigo
impressionism
infusoria
intaglio
Kepler's law
kilogram
kinesthetic
kinetic
Les Miserables
linotype
logos
luff
Malthus' law
metacarpal
midiron
Millet
mitosis
morgen
nada
natural selection
noi
ohm
parallax
peneplain
Pestalozzi
Polonius
pomology
puer
pyramidal tract
quadratics
rococo
R. S. V. P.
scherzo
semaphore
simony
spoils system
Stoicism
synecdoche
testudo
tort

trephine	vantage-in
triangulation	way-bill
trilobite	Weismannism
triple-expansion	wigwag
undistributed middle	X-Ray
Utopia	Zionism

Ask the subject to define all that have been marked in class of "roughly familiar." Make tables in which the results are compared with those of other subjects.

For those whose information is somewhat limited a much easier list will be necessary. An opposites test in which the subject is called upon to give exact opposites will also give considerable information as to the extent of the vocabulary.

An account of the papers, magazines, books and environment with which the subject is acquainted will give an idea of the expected size of his vocabulary.

An interesting exercise will be the arranging of a list suitable for various intelligence ages.

CHAPTER 17.

Memory

152. Economy in Memorizing

Select two pieces of literature of about equal difficulty such as two stanzas from the same poem. Memorize one selection by dividing into such parts as seem convenient. Memorize the first division, repeat it and add the next division. Continue this process until the selection is finally memorized. Record the number of minutes required. Consider it memorized as soon as you are able to repeat it correctly without looking at the book. Work as intently as possible and disregard any prejudice you may have in favor of either method.

After a brief rest period, memorize the second selection by reading it entirely through each time. Concentrate as strongly as you did on the first. Note the time as before. How do the two methods compare? A few hours later or a day later repeat the experiment with the same material to see if either method is better for final learning.

Materials—Poetry.

153. Measurement of Memory

Prepare a series of twelve nonsense syllables. These syllables are prepared by inserting

a vowel between two consonants, rejecting all those forming known words.

Start a metronome to beating 60 times a minute. At each beat read one of the syllables going through the series. Count each time you read the series through on your fingers or by dropping a card. At the first correct reproduction of the series the experiment is stopped and the number of repetitions required to learn the series recorded.

Numbers and letters can be used for this experiment.

After a given interval, say one hour, the series is relearned. The saving in the number of repetitions is noted.

Materials—Nonsense syllables, metronome.

154. Memory of Auditory Images

Prepare a series of cards by pasting (gummed numbers) one of the digits on each card. Use all the digits 1, 2, 3, 4, 5, 6, 7, 8, 9, 0, which will give you ten cards. The digits should be large enough so they can easily be read. Set a metronome so that it beats one stroke per second. The experimenter should shuffle his cards and arrange them so that there are not more than two numbers that appear in their regular consecutive order. Then take the cards and read one after each beat of the metro-

nome in a clear distinct uniform tone of voice. The observer listens until the experimenter is through with the series then writes the series on a sheet of paper. The records are preserved and compared with the original series. Omissions, deviations and insertions are counted and stand as the observer's errors. Deviations can be scored by counting the least number of steps that the number would have to be moved to put it in its proper place. It is well to ask the subject to close his lips firmly and place his tongue against the roof of his mouth to avoid the temptation to speak the numbers.

Materials—Cards with numbers, letters or nonsense syllables.

155. Memory for Various Forms of Images

Present the series in the same manner as in the former experiment, but have the subject write each number on a slip of paper in addition to speaking it aloud. Discard the paper and reproduce the series on another sheet. At least ten trials should be made for all the digit memory series.

Occasionally subjects will be able to remember all 10 of the digits in these experiments. It will be necessary to introduce part of a second set of cards, taking care not to repeat the same number twice in presenting them.

This series of experiments can be repeated

using letters or nonsense syllables instead of numbers.

Special apparatus is often found in laboratories for making the exposure of the memory material easy and more accurate.

Materials—Nonsense syllables, numbers, letters, metronome.

156. Memory for Various Forms of Images

Present the cards as in the former experiments, having the subject pronounce the numbers aloud as the card is laid down, in concert with the experimenter.

Materials—Cards with numbers, letters, nonsense syllables.

157. Memory of Visual Images

Use the same cards as were used for the Memory of Auditory Images. Instead of reading them to the subject, lay the cards down before him at the rate of one a second and have him write the series after they have all been thus presented. Lay the cards on top of each other and remove the series when the last card has been exposed 1 second.

Materials—Cards with numbers, letters, nonsense syllables.

158. Memory of a Series

Get a series of photographs (people un-

known to the observer) of the same size with the name on the back of the photo. Learn the name of one so the photo can be identified without reference to the name on the back. Add another, naming both. In a like manner learn to identify a third, always going over the series already learned. After once having learned to identify one never refer to the back of the card again. Mix the order in which the photos are presented always adding a new one to the series. The task of remembering the faces will seem easy for a time. After the series becomes longer some of those learned first will probably be forgotten. Give an explanation of your results.

Materials—A series of photographs.

159. Fidelity of Report

Tests designed to check the memory and imagination of the subject consists in presenting some series of objects or scene to him and by a carefully prepared list of questions note the amount and accuracy of the reproduction of the original scene or presentation. The presentation must be uniform and for a given time. Pictures are presented about one minute apart, although they may be shown as short a time as 5 seconds or as long as 7 minutes. A slightly modified form of Binet's card of objects consists of a sheet of orange yellow cardboard 35x 40 cm. upon which have been fastened two photographs, a label, a button, a penny and a

postage stamp. Simply state to the subject that you want to see how good his memory is. Let him look at the card 40 seconds, telling him to study it carefully as you will later inquire about all the little details.

After the subject has looked at the card ask him to answer as accurately as possible the following list of questions:

1. Did you notice a coin?
2. What was its denomination?
3. Did it show 'heads' or 'tails'?
4. Was it bright or dull?
5. Was it new or worn?
6. Did you see a button?
7. What was its shape and color?
8. What material was it made of?
9. How many holes were there in it?
10. How was it fastened to the cardboard?
11. Did you see the small picture near the top?
12. What color was it?
13. What did the picture represent?
14. What was its shape?
15. How many persons were in it?
16. What was the lady doing with her right hand?
17. What was the other person doing?
18. Is the title of the picture printed on it?
19. What is the man looking at?
20. What was the facial expression of the man?
21. Was there another picture? Where?

22. What was its shape?
23. How many persons were there in it?
24. How many animals are shown?
25. Is any part of any of the animals cut off by the margin of the picture?
26. Are there any words printed on this picture? What are they?
27. How are the people dressed?
28. What was in the foreground?
29. What was in the background?
30. At what season of the year was the picture taken? Why?
31. Did you see a postage stamp?
32. Was it American or Foreign?
33. What was its value? (denomination)
34. What color was it?
35. Was it new or had it been used?
36. Did you see a label?
37. What color was it?
38. What shape was it and approximately what size?
39. Was there any printing on it? Where? What?
40. Was there a border around the printing?
41. How were the various objects fastened to the cardboard?
42. What was the shape of the cardboard?
43. Was there any printing or writing on the cardboard? What?
44. What was the largest object fastened to the cardboard?

45. Did the cardboard rest on its narrow or wide side?
46. What object was nearest the edge of the cardboard?
47. What object did you notice first?
48. How were the various objects placed on the cardboard? Right side up or slanting or how?
49. Was there any frame around the cardboard?
50. What was the color of the cardboard?

The questions have been arranged in groups of five for each for ease in grading. The questions are suggestive only and must be adapted to the particular objects mounted on your card of objects.

160. Fidelity of Report of an Incident

Arrange a performance such as a quarrel, a fight, a class disturbance, etc., in which the objects and words used have been carefully prearranged. Let the incident come as a surprise to a group and after some time elapses ask a series of questions concerning the details of the affair.

The influence of suggestion may be studied by introducing questions concerning objects that really were not there, viz:—remove all erasers before the performance and let one of the questions be, How many erasers were at the black board?

These experiments have a direct bearing on the errors in evidence, reports, discrimination, etc. Modifications can be made and scenes selected illustrating many different incidents.

CHAPTER 18.

Affective Consciousness

161. Mental Analysis by the Association Time Method

Have two boxes just alike on the outside. In one of them place a bottle plainly labeled "Whisky" and a revolver. In the other box place a doll, a marble, a top and a jack-knife. Have these boxes placed in another room and ask the subject to look at the contents of only one of the boxes. It now becomes the problem of the experimenter to find out which box the subject opened. Make a list of 50 words to be used as stimulus words for free associations. In this list of 50 words have 10 that are closely related to the contents of the one box and 10 that are closely related to the contents of the other box. The remaining words should be irrelevant and just as well known as the related words. The subject should have no previous knowledge of the words to be given, but should be told to avoid words that would reveal his knowledge of either box. He should face the experimenter and give as quickly as possible the idea brought up by the stimulus word.

Keep a record of the stimulus word, associated word and association time. Average the time for the 30 unrelated words, the 10 words referring to the one box and the 10 referring to

the other. The words referring to the box seen will probably have a much longer average association time. Invent other problems to which this experiment can apply. The association times will be long enough to be measured by a stop watch if the more complicated apparatus is not available.

Materials—Boxes arranged as indicated in the experiment, stop watch.

162. Affective Consciousness, Comparative Method

Make a screen of dull grey color about 40 cm. square. Have two openings 10 cm. square placed near the center of the screen about 5 cm. apart. In these windows display colors comparing them with each other as to agreeableness.

Compare ten colors with each of the other colors and make a table of results:

	Pink	Red	Orange	Yellow	Blue	Purple	Violet
Pink							
Red							
Orange							
Yellow							
Green							

Mark the more agreeable + and the less agreeable —. Let the vertical column represent the color compared with the standard in the horizontal column. Add the plus signs horizontally and the minus signs vertically. The sum of

these two signs for any color will show the number of judgments in favor of that color. From the number of judgments obtained in favor of the colors make out the order of preference.

Materials—Grey screen, colored papers.

163. Affective Consciousness, Order of Merit Method

Take a series of ten picture post-cards representing landscape views. Ask some one to arrange them in order from the most beautiful to the one that seems least beautiful. Mark these cards with the letters A, B, C, D, E, F, G, H, I, J. Assign to the card selected as the most beautiful the highest number of the series, 10. The next one in order, 9; the least beautiful one would then be represented by 1; placing numbers under the respective letters representing the cards. Have at least ten different individuals classify the series recording the judgments. Average the judgments for each picture and find the mean variation. The highest average will represent the highest grade. A small mean variation will indicate a considerable agreement on the part of the subjects, while a large mean variation will show much disagreement. Reports of the opinions of the observers should reveal the reasons for the various judgments.

This method is splendid for finding the relative merit of hand-writing, advertisements, etc.

The reverse order of assigning values can also be used i.e. mark the highest rank 1; second in rank 2, and the poorest one the highest number in the series. This system, however, becomes awkward when the permanence of impression is to be measured by this method, for, some of the series will be entirely forgotten and a value will be hard to assign. With the method indicated above such a value becomes 0 and is averaged just the same as the other judgments. This method can be modified to meet various experimental problems.

Materials—Landscape views, advertisements, samples of handwriting, etc.

164. Aesthetic Division of a Line

Cut a strip of black paper 102.5 cm. long, 2.5 cm. wide and mount it on a white background. Take a strip of white paper 2.5 cm. wide and lay it across the line in such a manner as to divide the black line into two parts. Move the white line back and forth until the proportions of the two parts are most pleasing. Record the divisions made by a number of people and average the results. Reduce the proportions to as simple a fraction as possible. This experiment can also be used in the determination of the most pleasing proportions for an oblong, oval, etc.

Materials—A line or figure the proportions or shape of which can readily be changed.

165. Pneumograph Records

A pneumograph is placed upon the observer in such a manner as not to be obstructed by the clothing, back of the chair, or pressure against the table. The pneumograph is connected with a recording tambour which writes upon the smoked paper on a revolving kymograph drum. A time line showing seconds or fifths of a second should be traced simultaneously. After having adjusted the apparatus so as to make a good record, allow the subject to take on a normal resting attitude and get a pneumograph record. Then have the observer grip very hard, rest, read, rest, listen to a funny story, rest, smell of agreeable and disagreeable odors, etc. What fluctuations of breathing take place? Invent other conditions that will bring on various states of affective consciousness.

Materials—Pneumograph, tambour, kymograph, time marker, stories, problems, odors.

166. Plethysmographic Records

Repeat the former experiment substituting for the breathing tracing the tracing of the pulse. Then take both a breathing and a pulse tracing. Good circulation records are somewhat harder to get and great care must be taken to have all adjustments perfectly made.

Materials—Plethysmograph, recording tambour, kymograph, time marker.

167. Feeling and Unconscious Movement

The automatograph or swinging planchette consists of a wooden platform upon which the arm and hand can easily be rested. This platform is suspended from the ceiling. At the end on which the hand rests a stylus is inserted which writes on the glazed surface of a smoked

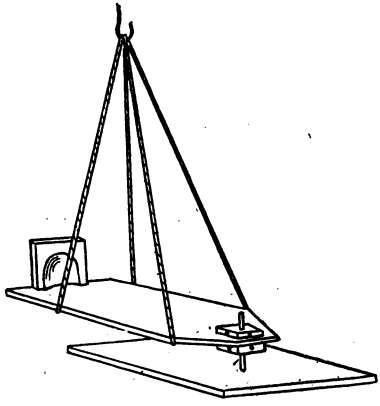


Fig. 51. Swinging Planchette.

sheet of paper lying beneath on a table. The paper has to be moved after each experiment The subject keeps his eyes closed throughout the experiments. At first a dreamy indifferent attitude should be taken by the observer, then various odors can be silently brought under the subject's nostrils. Some of these odors should be pleasant, others unpleasant, and the effect of each noted. Continue this experiment by describing journeys, etc., to the subject and see

if his hand involuntarily follows the direction you give. Notice the effect of watching a slowly swinging pendulum, rhythmic music, etc.

Materials—Swinging planchette, glazed paper, odors, pendulum.

168. Electrical Conductivity of the Body

It is a well known fact that the human body has a rather high resistance to the conduction of electricity. Some experiments seem to show that this resistance varies under different emotional attitudes. Connect a sensitive galvanometer and a weak dry cell in series. Lay zinc plates on the ends of the two wires. Lay the plate on the table or on the arms of a chair. The subject seats himself comfortably and sits very still. Place the hands on the plates taking care to hold them in the same positions. In the form of words, phrases, or questions, ask the subject to report his free associations. Give words to which the subject would be emotionally indifferent. Mix with them words that will likely stir up some emotional reactions. Record the galvanomic deflections for all the associations comparing the magnitude of the deflections for the indifferent associations with those accompanied by considerable emotion.

Materials—Galvanometer, dry cells, zinc plates.

Materials used in the Psychological Experiments. Numbers refer to the experiments.

Acoumeter, 41.

Advertisements, 163.

Alcohol lamp, 148.

Algometer, 19.

Atomizer, 92.

Boxes (different sizes of the same shape), 93.

Brass plate with standard holes, 89.

Brass strips, 90.

Brightness discrimination apparatus, 61.

Bristles, 8.

Bulbs (rubber), 119, 120.

Bunsen burner, 7, 11, 13.

Camel's hair brushes (pointed), 28, 30.

Campimeter, 64, 65.

Camphor gum, 34.

Candles, 57.

Cardboard, 21 (grey), 63, 68, 78, 79, 81, 82, 83, 162.

Chronoscope and accessories, 125, 126, 127, 128, 129, 130, 131, 132, 133, 134, 135, 136, 137, 138, 139, 140, 141, 142.

Cocaine, 30.

Coin, 12.

Colored papers, 67, 68, 76, 81, 82, 83, 134, 162.

Compass, 20, 22, 23, 24.

Corks (large), 102.

Cotton (absorbent), 26, 27.
Counter (electric), 84, 89.
Cylinder (metallic, pointed), 6, 7, 13.
Dark room, 57, 59.
Deep vessel, 14.
Discs (paper, colored, black, white, grey), 66, 67, 69, 70, 71, 72, 73, 74, 75, 76, 77.
Dissecting instruments, 3, 4, 5.
Drawing instruments, 102.
Dyes, 6, 7, 8, 9, 10.
Dynamometer (hand), 86.
Electric batteries (dry cells), 84, 89, 90.
Electric current (interrupted), 87.
Electric sounder, 90.
Ergograph, 94, 95, 96.
Ether, 92.
Exposure apparatus, 106, 107, 108, 109, 110, 115.
Eye-glasses (special stereoscopic), 104.
Felt, 91, 92.
Galton-Edlemann whistle, 53.
Galvanometer, 168.
Glass (colored and plain), 79.
Globe, 102.
Hairs, 8.
Heads of animals, 3.
Hinged board, 85.
Holmgreen worsteds, 63.
Graduated glasses, 27, 28, 29, 34.

Ice, 6, 7, 13.
Ink-blots, 150.
Kymograph, 119, 120, 121, 165, 166.
Lens (double convex), 57.
Letters (pied), 116.
Marble dust, 26, 27.
Marbles, 97.
Masson disc, 119.
Measuring disc (graduated in per cents), 66, 67, 69, 70, 71, 72, 73, 74, 75, 76, 77.
Metal plate, 84.
Metal rod, 84, 89.
Metronome, 94, 96, 99, 121, 122, 123, 124, 153, 154, 155, 156, 157.
Millimeter scale, 20, 21.
Mirror, 98, 113.
Musical instruments, 46, 49.
Odors, 35, 36, 37.
Paper discs, 167.
Pendulum, 167.
Perimeter, 64, 65.
Pictures (special), 104.
Pipettes, 32.
Photographs, 158.
Photometer, 59.
Planchette, 167.
Plethysmograph, 166.
Pneumograph, 165.

Pressure scale, pressure pain balance, 19.
Protractor, 85.
Puzzle pictures, 101.
Quinine, 27, 28, 29, 30, 31, 33.
Recorder (electric), 121.
Resonaters, 44, 49.
Rotator, 62, 66, 67, 69, 70, 71, 72, 73, 74, 75, 76, 77, 119.
Rotating platform, 38, 39, 40.
Rubber tube, 42, 46.
Salt, 26, 27, 28, 29, 30, 31, 32, 33.
Sand, 93.
Scale, 8, 27, 28.
Sheep heads, 4.
Skulls, 1.
Sonometer, 48.
Spinal cord (specimens of), 5.
Star (outlines of six pointed), 98.
Sterescope, 102, 103, 105.
Sterescopic slides (special), 103, (general), 105.
Sugar, 26, 27, 28, 29, 30, 31, 32, 33.
Tambour, 119, 120, 165, 166.
Tape measure, 41.
Target, 97.
Tartaric acid, 28, 29, 30, 31, 33.
Telegraph key, 121.
Time marker, 119, 120, 121, 165, 166.
Thermometer, 11, 18.

Thorns, 9, 10.
Tissue paper, 76.
Tracing paper, 6, 7, 8, 9, 10.
Tooth-picks, 6, 7, 8, 9, 10, 13.
Tuning forks, 42, 43, 44, 45, 46, 47, 50, 51, 52, 55, 56.
Watch, 12, 41, 57.
Wax, 8.
Vertebrae, 2.
Vinegar, 33.
Vision test charts, 60.
Weights, 88, 91, 92, 144.

General Supplies.

Alcohol, carbon paper, cards, clamps, electric current, ink, formalin, matches, millimeter, centimeter and meter measures, pans, paper (blank, cross-section, kymograph glazed), pencils, pens, pins, rods, screws, nails, tacks, etc.; stop-watch, tape-measures, thread, cord, tools (general metal and wood working), wire (binding and electric conduction), etc., etc.

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